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COGNITIVE INTERFERENCE IN REACTION TIME EXPERIMENTS

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DISSERTATION SUMMARY

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REACTION TIME EXPERIMENTS

av

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The present dissertation is based on the following four papers, referred to in the text by the respective Roman numerals.

- I Klintman, H. (1969). Contrast reaction time as an indicator of associativity. Psychol. Res. Bull., Lund Univ., 9, No 2.
- II Klintman, H. (1971). Cognitive interaction in the visual field - a reaction time study. Psychol. Res. Bull., Lund Univ., 11, No 5.
- III Klintman, H. (1973). Cognitive activity in the after-phase of perception as related to Spiral aftereffect duration. Psychol. Res. Bull., Lund Univ., 13, No 7.
- IV Klintman, H. (1975). Reaktionstid som indikator för subliminalitet. (Based on data from an unpublished paper of 1968 by the author. To be published.)

I n t r o d u c t i o n

The present series of studies all center on an experimental method and a principle of cognition. The principle has been termed here "cognitive interference", or sometimes "cognitive interaction" and can be conceived in its crudest form as stating that the process of cognition of a given stimulus is largely dependent on a background of cognitive activity set up by the individual's preceding or present transactions with his stimulus environment.

The existence of such a principle in its most general form is, of course, a commonplace. It involves ultimately the necessity for man to take advantage of past experience, a *sine qua non* for his survival.

The way in which such a principle operates, however, is by no means given, and is indeed the subject matter of many fields of psychology. In this present work a particular aspect of cognitive interference has been selected for study, viz., that which takes place in the process of identifying a given stimulus (S_2) as a function of another stimulus (S_1) preceding S_2 by less than a second.

To this end an experimental method was developed in which the effect of the cognitive quality (meaning) of S_1 on cognition of S_2 could be quantified by means of characteristic changes in the verbal reaction time (RT) for identifying S_2 .

This technique makes it possible to: a) define within narrow limits the temporal locus of the interference, and b) obtain measurements "closer to" the processes under study, i.e., less subjected to the uncertainties of, for instance, a phenomenological report given a relatively long time "after the fact".

The obvious drawback inherent in the RT measure in general is its natural lack of qualitative gradation. This means that, as far as cognitive interference is concerned, when using RT as a dependent

variable the structural aspect of the phenomenon must be inferred from its quantitative effects on response-time.

An assumption necessary for the usefulness of such a technique for assessing cognitive processes is, of course, that cognition of the meaning of a visual stimulus word occurs prior to the verbal response. In the case of non-reflexive reactions this assumption seems justified. Indeed, a state of having identified the word but not being able to name it was frequently reported by subjects as preceding the verbal response in these experiment. Also, the findings of Moore (1910 /quoted by Dixon, 1971, p.23/) sustain this view.

E x p e r i m e n t a l f i n d i n g s

In Study I the role of language associativity for cognitive interference from a first stimulus (S_1) with the identification of a second stimulus (S_2) presented about half a second after S_1 was demonstrated. The two stimuli (printed words) were shown to the subjects for a brief moment on a screen. The task was to read aloud as quickly as possible the second word and then report the first one. The RT to S_2 was recorded. Both stimuli were clearly supraliminal (always correctly identified).

The hypothesis that, for most subjects, the RT for identifying S_2 would be shorter in pairs of strongly associated than in pairs of weakly associated words was based on earlier findings that the degree of pre-experimental familiarity with the stimulus words (such as language frequency) affects their reaction times (Fraisse, 1963; Fraisse et al., 1963; Bevan & Dukes, 1953). While in such experiments stimulus experience concerned words identical with those used in the laboratory, the present study used a controlled design of associated, but not identical words in immediate temporal contiguity.

The results clearly indicated the role played by the presence of S_1 for the time needed for identifying S_a : an S_1 strongly associa-

ted with S_2 lowers the RT to S_2 as compared to conditions of low associativity. It was also demonstrated that the difference in RT between the two conditions of associativity was reduced if the same words were used repeatedly in the experiment. It seems that in this way a progressive change in associative strength may be operative, affecting pairs of weak associativity to a greater extent than those of strong associativity, as recordable in the RT to S_2 .

The relative decrease in the RT to S_2 in pairs of strong associativity is seen as an instance (positive) cognitive interference from the preceding identification of S_1 affecting identification of S_2 . The study lays down the basic paradigm for measuring cognitive interference in short-time contrast reactions. In the studies to follow, variations in the stimulus parameters of content, intensity, inter-stimulus time interval, and spatial locus will be undertaken and characteristic changes in the dependent variable, the time needed for identifying S_2 , recorded.

The interpretation of such changes will be used to infer the underlying cognitive processes.

In Study II the subjects were presented with a complex stimulus field, consisting of one central (S_c) and four peripheral (SS_p) stimulus words. Three conditions were used: 1). SS_p strongly associated with S_c , 2). SS_p weakly associated with S_c , and 3). SS_p consisting of nonsense syllables.

The SS_p were presented under marginal stimulus conditions, so that they might or might not be identified by the subject. The central word was always clearly supraliminal. The stimuli were shown together for a brief moment on a screen in front of the subject, whose task was to read aloud as quickly as possible the central word and then, if possible, report the peripheral words.

Thus under these conditions a stimulus field of varying associativity was created, with parts of it frequently lying just below the limen for correct identification.

It was hypothesized that during the cognitive processing of the field characteristic interaction would take place between the different parts of the field. Two specific hypotheses to this effect were advanced.

The results demonstrated firstly (hypothesis 1) how the probability of conscious identification of an S_p was increased by the identification of S_c if these stimuli were associatively related.

A question of interest here is the temporal locus of such facilitation. It might be argued, that the process takes place in connection with the subject's attempt to reproduce S_p , after first having identified and reported S_c . Thus if, for instance, only a few letters of S_p were primarily identified, the activation of the meaning area of S_c might increase the probability of later correct inference as to the correct word S_p in associative fields. In contrast, the facilitative effect might be presumed to have taken place during the process of identifying S_c , i.e., immediately following the stimulus exposure. In fact, this seems to have been the actual case. The rationale for this is based on the second finding (hypothesis 2) that a correctly identified S_p causes relative facilitation of the identification of S_c in fields of strong associativity. Since this facilitative interference must have taken place during the process of identification of S_c (the RT is dependent variable), and since it was present only in those trials where the associated S_p was also correctly reported, the implication appears to be that the crucial part of the facilitation has indeed occurred during that process. Otherwise, the relationship between "correctly reported S_p " and "difference between RT to S_c in high and low-associativity fields" would be hard to explain.

Finally, it was found that in general the time for identifying S_c increased as a function of the identification of an S_p .

The results indicated the presence of relatively complex cognitive interaction in a visual field of symbolic stimuli. In principle, the process of activation of the meaning of one part (S_1) of such a field tends to raise the level of activation of the meaning of another part (S_2) of the field if their meanings are associated. If S_2 by itself is just below the limen for correct identification, then the added facilitation might result in supraliminality of this stimulus. But conscious cognition of several parts of the field requires more time. Thus the supraliminality of an additional part acts inhibitably on the identification of the first. If maximum speed is required for responding, the subject will be working at the upper limit of his capacity for handling the information. An increase in the amount of relevant information per time unit of the kind used in this experiment will then bring about an increase in response time to the reaction stimulus.

In Study III the types of cognitive interference displayed by different subjects in a two-stimulus design (similar to that of study I) were related to their behavior in the Spiral Aftereffect (SAE) Test (Åndersson, 1969). The RT design involved the brief exposure of two stimuli (S_1 the name of a color, S_2 a color surface congruent or incongruent with the color named by S_1), separated in time by an interval of 650 ms. The two stimuli appeared around the same fixation point on a screen in front of the subject. The task was to name as quickly as possible surface S_2 and the also report word S_1 . The RT to S_2 was recorded.

In the SAE test the subject was asked to fixate a rotating spiral for 45 seconds. Following fixation the spiral was replaced by a stationary circle. The subject was to signal as soon as he noticed any changes in the perception of the circle. Typically the ensuing SAE is associated with perceived expansion of the circle.

A series of trials were given in succession, the duration of each SAE being recorded.

The basic hypothesis was that systematic individual differences existed in the type of cognitive interference present in the RT experiment, and that such differences might be related to behavior in the SAE situation. In addition it was suggested that it might be possible to analyse the SAE behavior in terms of a cognitive interference paradigm, thereby making way for the interpretation of any obtained co-variation of the results within the same conceptual system.

The results of the RT experiment disclosed one group of subjects with longer RT's to S_2 in incongruent than in congruent stimulus pairs ($D > 0$), and one somewhat smaller group with longer RT's in congruent than in incongruent pairs ($D < 0$). (The two groups together comprised all the subjects).

" $D > 0$ " was seen as the result of positive (facilitative) interference from the cognitive residual of the identification of color-name S_1 with the subsequent identification of color-surface S_2 if their relevant meanings were the same (congruence). Conversely, negative interference would take place in the case of different relevant meanings of the two stimuli (incongruence).

" $D < 0$ " was understood as resulting from a different type of interference: subjects with these D-values tended to inhibit selectively the cognitive residual (meaning) of S_1 immediately after identifying this stimulus. Consequently, if S_2 required the re-cognition of the same relevant meaning as that of S_1 , then such re-cognition would also be subjected to selective inhibition, i. e., more time would be required for its effectuation. On the other hand, in the case of incongruent pairs, the selective inhibition of the meaning of S_1 would not effect cognition of S_2 . Thus, if the inhibition were sufficiently powerful, the inequation $D < 0$ between congruent and incongruent pairs would result.

These two distinctive ways of handling the cognitive residual of the first stimulus, facilitation and inhibition, were incorporated as a "cognitive regulatory function" (CRF) in the system of cognitive interaction implied in this series of studies. Its mode of operation was found to be related to SAE-behavior to the effect that facilitation in the RT experiment was associated with a relatively high, and inhibition with a relatively low, amount of perceived SAE.

In order to make possible a unified interpretation of the results, an attempt was made to describe the SAE-situation in terms of its cognitive contents. The relevant stimuli (such as "spiral" or "circle") as well as their characteristics ("moving" or "not moving", "inwards" or "outwards") were noted, and the corresponding cognitive acts integrated in a system of the kind used in connection with the RT part. In this way, the extent of perceived SAE was seen as subjected to possible modification by the CRF acting on the cognitive residual of the perception of the rotating spiral.

The relationships of the results of the two experiments would then follow from the assumption of within-subject constancy of the CRF mode of operation.

In light of this analysis the fact that some aspects of the duration of the SAE have been found to be related to a higher organizational system ("personality") involving individual differences in cognitive-emotive functioning raised the possibility that the CRF might, to some extent be related to this system.

While the previously outlined interpretation of the personality-related part of the SAE variation is at best an interesting hypothesis until its further implications have been studied, the general finding of a relationship between the RT and the SAE experiments still remains. If in the RT part the cognitive residual of the perception of stimulus S_1 is seen as an "intraceptive event"

(Andersson, 1969; Andersson et al., 1971), albeit not necessarily a purely visual one, then the co-variation can be understood as an effect of facilitation (inhibition) of intraceptive events operative in both experiments.

As mentioned earlier, variations in SAE duration have successfully been related to personality. For instance, extremely long durations (at initial and final levels) of the aftereffect have been found foremost in subjects with anxiety-hysteric or dysthymic socio-emotional adjustment, in contradistinction to typically short durations, which seem to be characteristic of individuals of primitive-hysteric disposition. While the relationship between the results of the RT and SAE experiments for statistical reasons does not unconditionally mean that such a categorization can be reliably made solely on the basis of the RT results, the general direction of these results is still of interest: at the one extreme a "clinging to the meaning of the stimulus" is apparent, resulting in $D > 0$. Similar behavior, though observed in a different type of experiment, involving the description on a semantic differential of subliminal stimuli, has been found in subjects with a relatively high degree of manifest anxiety (Gordon, 1967). In the SAE test subjects with a $D > 0$ most frequently reported long aftereffect durations. The emotional adjustment of such subjects, as mentioned above, is characterized by anxiety-proneness. This is not inconsistent with the implications of their behavior in the RT experiment.

It was concluded that individual differences existed in the cognitive interference in the RT experiment, and that some of these, co-varying with SAE behavior, might be related to personality.

Study IV concerned the effect of a first stimulus (S_a) on RT to a second stimulus (S_b) in a meta-contrast situation. There were two hypotheses: 1). Unconscious cognition (identification) of the meaning of the subliminal S_a (the name of a color) interfere-

res with cognition of S_b (a color-surface) to the effect that congruence of their meanings facilitates, and incongruence hampers, correct identification of S_b , as indicated by the RT to this stimulus. 2). The RT to S_b is predictably longer when S_a is supraliminal than in the case of a subliminal S_a .

Both hypotheses were confirmed. The results were analysed in the light of past research on the "psychological refractory period", i.e., the prolongation of the RT to the second of two supraliminal stimuli in close temporal proximity as a function of the presence of the first stimulus.

The critique of the concept of subliminality was briefly reviewed. The contentions of critics a) that subliminal perception is in fact supraliminal perception of partial cues, b) that a subliminal stimulus is in fact a supraliminal one, the report of which is being withheld by the subject for various reasons, and c) that (unconscious) identification of stimulus A in a meta-contrast paradigm cannot take place during 75 ms or less after the exposure of this stimulus, were refuted on the basis of an analysis of the effect of the qualitative (content) and quantitative (temporal) characteristics of the cognition of stimulus A on the RT to stimulus B.

The temporal locus of the influence of the subliminal stimulus could be located to the process of identifying stimulus B, the implication being that the same is also generally true for phenomenological changes in stimulus B reported elsewhere (e.g. Smith & Henriksson, 1955).

S o m e i m p l i c a t i o n s

The picture conveyed by the results of this series of studies is one of pronounced interaction between processes of cognition in temporal contiguity. These processes may yield conscious experience or may be operating outside of the range of consciousness but still exercise their influence on other ongoing cognition.

An important aspect of this picture is the limitations of the capacity of the cognitive apparatus; if, for instance, too much stimulus information arrives in too short a period of time it will have to be sequentially processed, and a substantial delay of the identification of the last-arrived stimulus will result (Study IV). This is true first of all for the type of "extended processing" that leads to conscious (reportable) experience. In contrast, in the case of subliminal perception the identification of the stimulus is accomplished much more rapidly: identification of the meaning of a word, for instance, may occur in a matter of 60 ms or less, as compared to the 200 - 300 ms required for extended processing (i.e. leading to conscious experience) (Study IV). Such perception does not seem to encroach upon the limited system-capacity for extended processing to any great extent. Thus parallel processing of a supraliminal plus a subliminal stimulus would be possible without much delay in responding to the former (Study II).

The principles apparent in the results of the four studies, employing variations in the cognitive interference paradigm, and using external (stimulus) control of conscious and unconscious cognition, very likely have their counterparts, not only in the individual's everyday transactions with his external environment, but, also in the dynamics of associative thinking not directly under such control. One suggestive example is based on Study II:

In our cognitive response to a complex visual field, interaction between the meanings of the parts of that field can readily be observed. The type of interference resulting in the elevation of a primarily subliminal peripheral stimulus to supraliminality as a function of simultaneous identification of an associated focal supraliminal stimulus has a possible implication for the interpretation of the act of association: if we replace "cognition of peripheral subliminal stimuli" by "unconscious cognitive activities of defined meaning" varying in associative relatedness to a "focal (conscious) activity" (likewise of specified meaning) ,

then it seems a plausible generalization that these unconscious activities would receive "cognitive implementation" in proportion to their relatedness to the focal activity. If such implementation were sufficiently powerful, the several related unconscious activities would approach the limen for conscious experience. But the one reaching it first (50 ms or less) would thereby occupy the channel of focal attention and, for the moment, block further progress of the competing associates. In a chain-association task these latter might or might not follow the first in the conscious stream of thought, since the first, now the focal concept, would implement cognition of associated concepts in proportion to their relatedness to it.

Mechanisms of this kind may be helpful in accounting for data like those of Varendonck (1921), who using a free-association technique demonstrated how the interruption of the conscious stream of thought by an "invading" thought would occur apparently as an effect of the latter being raised to consciousness as a consequence of associative implementation by the former.

If we subject some of the findings of Study IV to the same kind of generalization, then S_a could be replaced by the necessary structural conditions for a specified meaning to be activated toward the limen for conscious experience. If, however, there also existed another concept-meaning, active on a level closer to the limen than the first, and associatively related to it, then the increased activity of the first might raise the second to limen before the former itself reached it. Again, there would be a blocking of the first by the second from conscious experience, as well as uncertainty as to whether the former would actually become conscious after the first had left the channel. In other words, increased unconscious activity of the first concept-meaning would trigger off conscious cognition of the second and by doing so would exclude itself from conscious representation.

The necessary assumption here that activation on an unconscious level of one concept-meaning leads to the activation of associated meanings, is supported by the findings of Spence and Bressler (1962) who demonstrate such a mechanism in a response latency experiment.

The role of individual differences in handling cognitive (and emotional) material is, of course, a fundamental one. While general principles do exist, the versatility of individual solutions is often impressive. Conscious cognition of a concept facilitates as a rule cognition of a related concept actualized, say, a half-second later (Study I). But when it comes to recognition of the self-same concept (by definition the one with the strongest associative support) some subjects find it relatively more difficult to perform this act (Study III), while others seem to "cling to the meaning" of the first stimulus (possibly to the exclusion of other associative activity). If transposed to the associative stream of thought not immediately under external stimulus control, such a difference surely would be of consequence. Stated very crudely, the stream of thought would in the one case tend to be more restricted, centering on relatively few core-concepts or clusters. In the contrasting case a tendency toward a more "volatile" mode of thinking, full of associative ramifications, would be the rule.

These examples are only meant as suggestive of a possible way of generalizing some of the findings of these studies. In a system of diversified unconscious activity on levels nearer to, or farther away from, the limen for conscious experience and of varying strength of associative relatedness, - a system partly controlled by external stimulation - the application of the concept of cognitive interaction, in the restricted sense used here, seems reasonable.

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PSYCHOLOGICAL RESEARCH BULLETIN

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*Contrast reaction time as an indicator
of associativity*

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Abstract. - Verbal reaction time to the second of two successive printed words was measured by means of a voice-key. The two stimuli were varied in regard to the strength of association between their meanings. The results suggest that the latency for reading the second word is shorter when the pair consists of closely related words. Furthermore, if the subjects were pre-informed about the experimental words this difference decreased as compared with naïve subjects. The results were integrated with some known facts concerning the effect of language frequency and stimulus familiarity on reaction time to single verbal stimuli.

Problem

In studying the influence of stimulus experience on reaction time (RT) to single verbal stimuli, relationships have been found with the language frequency of the word (Fraisse, 1963; Klintman, 1968a) as well as with its rated familiarity (Fraisse *et al.*, 1963). It has also been demonstrated that the subject's preknowledge of the experimental stimulus reduces the reaction time (Bevan & Dukes, 1953). The last point has been further explored in an experiment in which a series of 40 stimulus words were presented three times in succession. Responding to the first series gave rise to an augmented readiness for these words so that the reaction time during the two replications was clearly reduced (Klintman, 1968a). In experiments on the psychological refractory period - in which two stimuli are presented in succession and changes in the reaction time to the second one are recorded as a function of the time interval between them - the role of the subject's expectancy about the length of the interstimulus interval has been indicated (Elithorn & Lawrence, 1955; Nickerson, 1965).

In terms of the stimulus experience of the subject it thus appears that the RT is a function of experience accumulated outside the experimental situation (e.g., linguistic contact frequency when using verbal stimuli) as well as of experience stemming from the design and stimulus pattern of the experiment and the subject's interpretation thereof (e.g. knowledge or expectancy about the stimuli or the time for their incidence). The former class of experience will be referred to as distal and the latter as proximal.

The aim of the present study is to determine whether the distal experience of associative relatedness of various strength between two sequentially presented verbal stimuli (S_1 and S_2) affects the RT to the second of them. Specifically, the question is asked whether the presence of S_1 (contrast stimulus) immediately prior to S_2 (reaction stimulus) will interfere with the RT to S_2 in a mode that may be predicted from the knowledge of the degree of association (associativity) between the meanings of the words.

Thus the relevant proximal stimulus experience consists of the presence of the contrast stimulus, while the distal experience is defined by the degree of general linguistic associativity between the two stimulus words.

By contrast reaction time (CRT) is meant the reaction time to a stimulus (S_2) preceded by a specified contrast stimulus (S_1).

In an earlier experiment (Klintman, 1968b) in which a contrast stimulus (the printed name of a color) was presented subliminally 40 ms before the reaction stimulus (a homogeneous surface the color of which was to be named) the latency was found to be shorter when the stimuli were congruous (same color) than when they were discrepant. The experiment seems to demonstrate a case of cognitive interference between the meanings of two stimuli in temporal contiguity.

In the present experiments such interference is further investigated, this time employing supraliminal stimuli only, with the following hypothesis:

The RT for reading the second of two printed words presented in immediate succession is shorter if the associativity between the words is high than if it is low.

Two experiments are performed. In Exp. I the number of stimulus words is small and the subjects are informed in advance about which words will be used. S_1 and S_2 form all possible combinations of these words. Each combination recurs several times during the course of the experiment. In Exp. II a greater number of words are employed. Each stimulus pair is presented only once and the subjects are not informed about what

words will be presented.

EXPERIMENT I

Method

Material. The stimulus material included slide projections of six Swedish words. They were printed in capital letters in white against a black background. The words were projected on a ground-glass screen. Their height was 35 mm and maximum length 100 mm. The light intensity was chosen so as to facilitate stimulus identification. The experimental words were divided into two groups: Group I including the words BIL (car), RATT (steering-wheel), HJUL (wheel), and Group II including the words BOK (book), RAD (line, row), PÄRM (cover/of a book/). By definition every pair made up of words from the same group was characterized by high associativity. Contrariwise, those pairs were of low associativity which consisted of words from different groups. The choice of the experimental words has been made intuitively as regards the strength of association. Thus inspection of the above groups reveals two clusters of associatively related words. A more sophisticated technique for measuring the strength of association was not considered necessary at this stage of investigation.

Apparatus. Two slide projectors equipped with fast-operating hydrogen lamps were fed with pairs of impulses from an electric timer. In parallel with one of the projectors was connected an electric chronometer (mark FAVAG, calibrated 1/100 sec.) which was activated by the impulse to the projector. In front of the subject was placed a microphone which via amplifier and relay closed a stopping-circuit in the chronometer on receiving sound. The projectors were loaded with the two stimulus words forming a pair of high or low associativity. At each presentation a sequence of the two stimulus words ($S_a S_b$) was shown. The chronometer measured the time between the exposure of S_b and the subject's reading this word. Each stimulus word was exposed for 50 ms. The time interval between the words in a pair was 350 ms. The subject was seated 170 cm in front of the screen, and the projectors were placed 120 cm behind the screen.

Design. The subjects were 31 female students of psychology (first year course), aged 19 to 25 years. Their task was to read as quickly as possible the second of the two successive words and then name the first one as well so as to make clear that it had been correctly perceived. The reaction time for reading the second word was measured.

The experiment was initiated with a warming-up series in which the experimental words were presented to the subject. Following this, the main part was performed during which every one of the 30 possible permutations of the 6 words was presented in three identical series. In this manner each of the three series came to include 12 pairs of high and 18 pairs of low associative strength. Within the series the pairs were distributed so as to eliminate any one-sided position effect. Otherwise the distribution was unsystematic so as to reduce stimulus anticipation. The time interval between the presentation of two stimulus pairs was about 10 seconds.

As a dependent variable was chosen the median RT of the three presentations of a given stimulus pair. Furthermore, typically anomalous reactions were omitted (58 out of 2790 measurements > 750 ms). In cases of incorrect stimulus report the measurement was excluded and the pair in question repeated at the end of the series (a few cases only).

Instruction. The following instruction was given orally. The subjects were told to wear their glasses if they normally used them.

"The purpose of this experiment is to measure your speed of reaction to words which will be shown on this screen. You will be presented with two words in immediate succession. Your task will be to read aloud the second of the two words as quickly as possible and then mention the first one as well. The time for your reaction to the second word will be measured and it is important that you react as fast as possible to this word. Some second before the words are exposed I shall say 'now'. Then look firmly at this point on the screen ", (indicating). "The words will be shown to you on this surface", (indicating). "Should you happen to blink or otherwise be unprepared at the moment of exposure, please report this directly. Speak loud and concisely into the microphone. Any questions? Then let's start with a warming-up series." (Then:) "We shall now proceed to the main part of the experiment. You will be presented with various combinations of these words. As you know, the second one is to be read before the first one. Try not to think about any specific word before the presentations. Let's begin."

Results

The computations are based on each subject's median RT of the three presentations of the respective stimulus pairs. In the first analysis, for each subject the means of these medians have been compared between pairs of high and pairs of low associativity. The resulting differences have been tested under the hypothesis of shorter RT for pairs of high than for pairs of low associativity. This test is summarized in Table I.

Table I: Summary of T-test of the difference between the two correlated series of each subject's averaged RT for stimulus pairs of high and low associativity. Time in ms. One-tailed test.

Mean diff.	σ_{est}	T	Df	P
-6.93	3.14	2.21	30	<.025

The mean RT of the group was 527.0 ms for pairs of high and 533.9 ms for pairs of low associativity. According to Table I the hypothesis is accepted at the 2.5 % level of significance.

In applying the T-test the stimulus material was held constant over the two contrasted conditions of associativity. That is, all the stimulus words were used under both conditions and a proportionally equal number of times as contrast and reaction stimulus. In this manner the specific stimulus factor was controlled.

A somewhat more detailed analysis of the material was also undertaken. In this design the contrast stimulus was varied from high to low associativity while reaction stimulus and word-length contrast (the difference in the number of letters between S_1 and S_2) were both held constant. To this end, the stimulus material has been organized as in Table II. It should also be noted that language frequency is practically constant between the two conditions of associativity (Hassler-Göransson, 1966).

Table II: Organization of the stimulus material. The 12 pairs are matched into 6 dyads in respect to reaction stimulus, language frequency and word-length contrast.

High associativity		Low associativity	
S ₁	S ₂	S ₁	S ₂
BOK	RAD	BIL	RAD
BIL	RATT	BOK	RATT
BOK	PÄRM	BIL	PÄRM
BIL	HJUL	BOK	HJUL
PÄRM	BOK	RATT	BOK
RATT	BIL	PÄRM	BIL

In this manner the RT to "RAD" in the pair BOK-RAD was compared with that of "RAD" in the pair BIL-RAD, the RT to "RATT" in the pair BIL-RATT with "RATT" in the pair BOK-RATT etc. These data were then subjected to an analysis of variance using an A x B x S design (Lindquist, 1953, p. 237). A summary of the analysis will be found in Table III.

Table III: Summary of analysis of variance of the effect of associativity (C) and differences between the stimulus pairs (B).

Source of variance	Sum of squares	Df	Est. variance	F	P
Subjects (A)	16195.90	30	539.86		
Stimulus pairs (B)	98.79	5	19.76	2.02	n.s.
Associativity (C)	53.45	1	53.45	7.01	< .05
A x B	1467.46	150	9.78		
A x C	228.46	30	7.62		
B x C	74.18	5	14.84	2.09	n.s.
A x B x C	1063.41	150	7.09		
Total	19181.65	371			

Table III reveals an effect in factor C (associativity) similar to that in Table I. The average difference in RT between pairs of high and low associativity is here 7.6 ms in the expected direction. The differences between the stimulus pairs do not reach a level of statistical significance ($P > .05$),

nor does the interaction stimulus pairs x associativity.

In the total stimulus material the distribution of the effect of high associativity was such that out of the 31 subjects 20 decreased, 9 increased, and 2 retained unchanged their RT. The corresponding figures for the material in Table II were 23, 7 and 1. The contrast 21/10 and 23/8 give values of $P < .05$ and $P < .001$, binomially (one-tailed test).

Accordingly, the hypothesis is verified. The presence of a highly associative contrast stimulus immediately prior to the reaction stimulus results in a reaction time shorter than that in the case of a contrast stimulus of low associativity.

At the beginning of this experiment the subjects were allowed to familiarize themselves with the stimulus material. Several measurements were then made with identical stimulus pairs. However, as we shall see later, from a technical point of view this procedure might well have entailed a complication i. e. that to the subject the relative strength of associativity within pairs of distally unrelated words may have increased. The repeated display of every word together with every other word may tend to level distal differences in associativity. Nevertheless, even if this be the case, there remains a recordable contrast in performance under the two conditions.

EXPERIMENT II

Method

Material. The experimental stimuli were slide projections of 28 Swedish words. They were presented under the same external conditions as those in Exp. I (above). The words were divided into two categories: 7 pairs were of high and 7 pairs of low associativity (Table IV).

Table IV: The experimental stimuli organized in pairs of high and low associativity. English translations within brackets.

High associativity		Low associativity	
S ₁	S ₂	S ₁	S ₂
ELD (fire)	VARM (hot)	TAL (speech)	STOR (large)
DAG (day)	LJUS (light)	RAD (line)	HÖGT (high)
PÄRM (cover)	BOK (book)	NATT (night)	HEL (whole)
STEN (stone)	TUNG (heavy)	BÅT (boat)	MUN (mouth)
TRÄD (tree)	BLAD (leaf)	BUSS (bus)	HAND (hand)
RATT (steering-wheel)	BIL (car)	STRECK (line)	LITEN (small)
HÖGER (right)	VÄNSTER (left)	MOLN (cloud)	PAPPER (paper)

As in Exp. I the stimulus pairs were chosen intuitively as regards their internal associativity. Clearly, the two groups in Table IV seem to differ in this respect. Also, the groups have been matched according to word-length contrast and language frequency (Hassler-Göransson, 1966).

This means that the differences in the number of letters between word 1 and word 2 are equal in both groups and that the language frequency within the pairs has been balanced according to the results from earlier investigations concerning its effect on RT (above).

Apparatus. The same apparatus was used as in Exp. I (above). Each stimulus word was exposed for 50 ms. The time interval between the two words in a pair was 350 ms.

Design. The subjects were 8 female students of psychology (first year course), aged 19 to 25 years. As in Exp. I their task was to read aloud into the microphone the second of the two successive words as quickly as possible and then add the first one. The experiment was initiated with a warming-up series using figure-names for stimuli. During the following main part each pair of words (Table IV) was presented only once. The subjects were not informed about the stimulus words beforehand.

The time interval between two pairs was about 10 seconds. Within the series of presentation the pairs were distributed with a view to avoiding any one-sided position effect on either of the stimulus categories. Otherwise, the distribution was unsystematic so as to reduce undue anticipation. Three anomalous reactions (≥ 900 ms) were omitted.

Instruction. The following oral instruction was given. The subjects were asked to wear glasses if they normally used them.

"The purpose of this experiment is to measure your speed of reaction to words which will be shown on this screen. You will be presented with two words in immediate succession. Your task will be to read aloud the second of the two words as quickly as possible and then mention the first one as well. The time for your reaction to the second word will be measured and it is important that you react as fast as possible to this word. Some second before the words are exposed I shall say 'now'. Then look firmly at this point on the screen", (indicating). "The words will be shown to you on this surface", (indicating). "Should you happen to blink or otherwise be unprepared at the moment of exposure, please report this directly. Speak loud and concisely into the microphone. Any questions? Then let's start with a warming-up series." (Then:) "We shall now proceed to the main part of the experiment. You will be presented with combinations of various words. As you know, the second one is to be read before the first one. Try not to think about any specific word before the presentations. Let's begin."

Results

For each subject the median RT to pairs of high and low associativity has been compared. A T-test has been applied to the resulting differences (Table V). The nature of the hypothesis (above) has justified a one-tailed test.

Table V: Summary of T-test of the difference between the two correlated series of each subject's median RT for stimulus pairs of high and low associativity. Time in ms. One-tailed test.

Mean diff.	σ_{est}	T	Df	P
-28.75	6.49	4.42	7	< .005

The mean RT of the group was 561.3 ms for pairs of high and 590.0 ms for pairs of low associativity. A significant difference between the two stimulus conditions appears (Table V). All 8 subjects gave shorter reaction times to pairs of high than to pairs of low associativity ($P < .01$, binomially).

Thus, the hypothesis is confirmed at the 0.5% level of significance. The RT to the second word is shorter in the pairs of high than in the pairs of low internal associativity. The experiment shows that this is so even if the subject has no preknowledge of the stimulus words to be used. The observed effect is definitely more pronounced than that recorded in Exp. I ($P < .001$, T-test, two-tailed).

Discussion

The results indicate that the speed of reaction to the second word is higher when the associative relation between the words is strong than when it is weak. In both experiments language frequency and word-length contrast were under control. A difference between the results of the two experiments exists in that the same effect is more prominent in Exp. II.

In using the voice-key technique for registering verbal responses differences in observed reaction time between two words may sometimes be ascribed to their phonetics: for example, if a word begins with a group of unvoiced consonants these may pass without any effect on the registering mechanism. On the other hand, a word beginning with a vowel will affect the relay immediately. However, in the present experiments the orthography of the words is such that the groups of high- and low-associativity pairs are equal in this respect. Moreover, the fact that the difference in RT between pairs of high and low associativity is not contingent on differences in orthography between the specific words is clearly indicated by the results in Table II (Exp. I) where the two categories of associativity are compared and reaction stimulus held constant.

Another problem concerns response attitudes. Aware that a highly associative word may follow the first one, might the subject by guessing prematurely initiate a response which in a certain number of cases ac-

cords with the exposed reaction stimulus? This would probably reduce the average reaction time to pairs of high associativity. However, since the subject in Exp. I was well aware of the stimulus words but naïve in this respect in Exp. II, this interpretation would seem to predict a greater effect of associativity for Exp. I rather than for Exp. II. In Exp. I, given a contrast word, only two reaction words of high associativity were possible. In Exp. II the number of possible reaction words of high associativity for a given contrast word was considerably greater (e.g., FIRE - hot, burn, spark, red, flame, stove, hearth; TREE - leaf, trunk, wood, forest, branch, twig, root). Consequently, as one compares the results from the two experiments it seems unlikely that the observed difference in RT between pairs of high and low associativity should have originated from such anticipatory response behavior. Finally, had this nevertheless been the case and in only one of the experiments no difference in RT between the categories should be expected in the other.

The results seem rather to indicate that perceiving the contrast stimulus facilitates the following process of perceiving and reacting to the reaction stimulus. The crucial factor thus would be the high associativity between the words.

The differences between the results of Exp. I and Exp. II may be viewed as a consequence of different experimental conditions: in Exp. I the subject was informed about the possible stimulus words; these were presented before the main experiment. In the latter all possible pairs formed by these words occurred several times. In Exp. II the uninformed subjects were presented with each pair of words only once. In Exp. I the design may have led to a levelling of the differences between pairs of high and low associativity in that distally unassociated words may have received a certain amount of mutual association. If so, the effect of the corresponding change in the pairs of high distal associativity must be assumed to be less pronounced than in pairs of low associativity. This would lead to the above-mentioned levelling effect. Indeed, some of the principles concerning language frequency and RT to single verbal stimuli seem to apply: within the high frequency range the RT is only slightly affected by changes in frequency, whereas at low frequencies the speed

of reaction is appreciably more sensitive to changes. In fact, this frequency effect tends to be logarithmic (Fraisse, 1963) and is likewise observed in naming objects when the language frequency of the object names is used as an independent variable (Oldfield & Wingfield, 1965). It seems possible that a similar case could be made for the contrast reactions in the present experiments: "associativity between word A and word B" may here be conceived of as the amount of experience or familiarity with word B (or what it symbolizes) in context with word A (or what it symbolizes). In Exp. I the change in associativity brought about by the characteristics of its design pointed out above would then, in the case of pairs of low distal associativity, due to their initially low frequency in the subject's experience cause a relatively large reduction in the contrast reaction time. Contrariwise, in the case of pairs of distally high associativity the reaction time would not decrease to an equal extent since their frequency was initially high. In Exp. I this would mean that the difference in reaction time between the two categories of association would tend to diminish. On the other hand, in Exp. II, due to its design (above), the requirements for such a levelling process would not exist. Hence the differences between the results of the two experiments.

The above suggested application of the concepts of frequency and familiarity to associativity in interpreting results obtained with the described contrast reaction technique leads to specified predictions about the CRT as a function of the associativity within the stimulus pairs. With a suitable index of associativity (e.g., frequency of word A in context with word B: rated familiarity of word B in relation to word A) it might prove possible to obtain functions empirically which can be derived from facts and theory concerning single verbal reactions.

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Cognitive Interaction in the Visual Field
— *a Reaction Time Study*

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Abstract. - The subject was presented with a series of three different stimulus fields each consisting of one central word (S_C) surrounded by four peripheral ones (S_P). The fields differed with respect to the strength of association between the five component words. These were presented simultaneously, the peripheral words under marginal stimulus conditions. The reaction time (RT) to S_C was measured and the number of S_P identified was counted. The results indicate a positive relationship between field associativity and the number of S_P identified. Moreover, when an S_P was identified, the RT to S_C was shorter in high than in low associativity fields. In these latter, identifying an S_P increased the RT to S_C . - The results are discussed in terms of cognitive interaction between parallel processes of stimulus identification in a system of limited capacity.

Problem

This study is one in a series concerned with cognitive interference in the perception of a complex spatial or temporal stimulus field. In an earlier paper (Klintman, 1969) it was shown that increasing the strength of association between the meanings of two stimulus words presented in succession (interval 350 ms) decreases the RT (reaction time) to the second word. The results indicated facilitation in the identification of this second word due to (a) the existence of an aftereffect of the first word being identified and (b) the spread of this effect to functions regulating the identification of stimuli with meanings associated with this first word. Similar results have been obtained for the identification of colors (Klintman, 1970).

While these experiments used successive presentation of stimuli, the present work is concerned with cognitive interference in a

spatial field consisting of several simultaneously presented stimuli. An attempt is made to answer the following questions:

- (a) Is there a positive relationship between the number of stimuli identified in such a spatial field and the associative strength between the meanings of the stimuli?
- (b) Can the RT for identifying a given stimulus in such a field be decreased by increasing the strength of association between the meanings of the stimuli? If so, how is this RT affected by the simultaneous identification of still another stimulus in the field?

It will be assumed, with the instructions given, that if a subject does not report a stimulus word he has been less conscious or sure of its identity than he would have been if he had in fact reported it. By implication then, an unreported word is said to be "unidentified"; a reported one is, of course, "identified".

Stimulus identification is conceived of as a process, requiring of necessity time. It begins at the moment of stimulation and continues with the development and gradual differentiation of the percept. Associative reactions to the stimulus pattern are made until at last a degree of consciousness concerning the identity of the stimulus is reached sufficient to elicit a verbal response. If the stimulus is too weak or the attention of the subject is not on the stimulus, the final stage may never be reached. Neurophysiologically the process of perceiving and responding to a simple stimulus has been studied by Monnier (1952). The analysis of the evolving percept is suggested by Smith (1957, 1963). The basis of the specific questions above lies in the postulate that if two or more processes of stimulus identification occur simultaneously there is a certain degree of interaction between them.

Method

Material. Each stimulus field (F) consisted of 5 words or groups of consonants in light print exposed simultaneously for 40 ms on a semi-transparent screen: 1 central word (S_c) and 4 peripheral ones (S_p) placed in fixed positions around S_c . The fields were of three types or categories: I: Strong associative relation between the meanings of S_c and S_p (field with high associativity, F_h). II: Weak associative relation between S_c and S_p (field with low associativity, F_l). Only meaningful words are contained in fields I and II. III: S_c was a meaningful word and the four S_p meaningless groups of consonants (field with no associativity, F_n). Sixteen different stimulus fields of each type were represented in the experiment. A given word or group of consonants was presented to the subject only once. The central words were matched over the three categories with regard to language-frequency (Hassler-Göransson, 1966) and word-length. The peripheral words were matched with regard to word-length and position relative to S_c . (This entailed a minor difference in language-frequency between the categories which could be shown, however, to be negligible (see below)). The groups of consonants in category III were matched with the corresponding words in categories I and II with regard to number of letters and position relative to S_c . Examples of stimulus fields from the three categories are given in Fig. 1. The length of each word on the screen was between 3.5 and 5.0 cm, the letter being 1.0 cm tall. Each field was closely fitted within an area 6 cm high and 13 cm wide.

(I)	(II)	(III)
HET VARM	HÖG NOGA	THM RVMK
ELD	ARM	ÄGG
BRAND RÖK	FÅGEL ASK	NRBDS KRB

Fig. 1 Examples of stimulus fields from the three categories of associative strength: (I) high, (II) low, and (III) no

associativity. The words in English translation: FIRE (I, central), HOT/WARM/CONFLAGRATION/SMOKE (I, peripheral); ARM (II, central), HIGH/CAREFUL/BIRD/BOX (II, peripheral); EGG (III, central).

All of the central words were mono-syllabic, less than 6 letters in length and with a median language-frequency of 15 per 400 000 words. The peripheral words contained between 2 and 9 letters, the median language-frequency being 11 per 400 000 words. The words in categories (I) and (II) were chosen so as to render a clear-cut difference in associativity between these fields, obvious immediately upon inspection (Fig. 1).

Apparatus. A slide-projector equipped with a fast-operating hydrogen bulb was fed with impulses from an electric timer. An electric chronometer (make FAVAG, calibrated at 1/100 sec.) was connected in parallel with the projector and was activated by the impulse to the projector. A microphone placed in front of the subjects closed a stopping-circuit in the chronometer via amplifier and relay, on receiving sound. The chronometer measured the time interval between the brief projection of the stimulus field on the screen and the subject's beginning to read aloud the central word. The subject was seated 135 cm in front of the screen, 120 cm behind which the projector was placed.

Design. The subjects were 12 male och 12 female university students aged 19 to 25 years. Their task was to read aloud into a microphone, naming the central word in the field as quickly as possible and then reporting which, if any, of the peripheral words they had also identified. Each subject was presented with a series of 48 exposures of different stimulus fields, 16 belonging to each category of associativity. The order of presentation was randomized as regards the categories. Before the main series was initiated

a few warm-up trials were given without any special notice.

The exposure time for each field was 40 ms. The light intensity was equal for all stimulus words. Time and intensity were chosen so as to facilitate the identification of S_c by the subject. The values of the parameters just mentioned were also chosen so as to reduce for the average subject the proportion of trials in which an S_p was reported to somewhere around 1/4. Thus, a subject may or may not identify a given S_p and his attention ('perceptual readiness', 'concentration on the task') becomes a factor of consequence to such identification. Adequate values for the parameters concerned had been established in a minor pilot-study.

The time interval between successive exposures was 10 seconds. Two dependent variables were employed: (1) the subject's RT for initiating the reading of the central word, and (2) the proportion of the subject's trials followed by correct report and by no report of a peripheral word respectively. The independent variable was the degree of associativity in the stimulus field (high, low, or none). Each subject worked under all three conditions. Individual difference measures were thus obtained and the subject factor controlled. Some typically anomalous RTs (>1000 ms) were excluded (fewer than 1 per subject).

Instruction. The following instruction was given orally. The subjects were told to wear their glasses if they normally used them.

"The purpose of this experiment is to measure your speed of reaction to a word when it is surrounded by other words or letters. You will be presented with one central word (here)" - indicating - "and at the same time with four other words or groups of letters (here). Your task will always be to read aloud the central word as quickly as possible after it is shown. In most cases you will not be able to identify the surrounding words. In fact, this does not belong to your task. However, in some cases it may happen that you

catch some of them. If you do, it is important that you report that word at once. But remember that your task is to read the central word and not the peripheral ones. Throughout the experiment you should try to respond to that word as quickly as possible. - A few seconds before each exposure I will say 'now'. Then look steadily at this point on the screen" - indicate - " and keep doing so until you have responded. Read out the central word as quickly as possible into the microphone. Speak loudly and clearly. Any questions? - Let's begin".

Results

Table I shows the distribution of trials with correct and incorrect reports and no report of a peripheral word or group of letters for the three categories of field associativity.

Table I: The percentage of trials with correct and incorrect reports and no report of a peripheral word (or group of letters in category III) in stimulus fields of varying associativity.

Associativity	Report		
	Correct	Incorrect	None
(I) High (F_h)	<u>48.1</u>	6.7	<u>45.2</u>
(II) Low (F_l)	<u>15.1</u>	11.7	<u>73.2</u>
(III) None (F_n)	.0	11.8	88.2

The underlined figures in Table I are those particularly relevant to the problem under study. The trend is pervasive: of the 24 subjects, 20 scored a higher percentage of trials with correct report of an S_p in fields of high than in fields of low associativity; in no case was the reverse true; in 4 cases there was no difference ($P < 0.005$, one-tailed Wilcoxon matched-pairs signed-ranks test). In fields of high associativity 11 subjects made occasional reports of more than one S_p in a trial. In fields of low associativity only one subject did so. As a rule the reports contained only one S_p .

Since the language frequency of the peripheral words may be of consequence to their identification, the possible effect of a minor discrepancy between the fields (medians were 16 and 7 per 400 000 for F_h and F_l respectively) was examined: for each of the two categories, fields with high and those with low associativity, the 25% containing the most frequent and the 25% containing the least frequent peripheral words were selected. The resulting median frequencies for F_h were 53 per 400 000 in the upper and 7 per 400 000 in the lower quartile. For F_l these medians were 33 per 400 000 and 3 per 400 000, respectively. For F_h the average number of trials with correct report of an S_p was 2.48 in the upper and 2.24 in the lower quartile, the corresponding figures for F_l being 1.13 and 1.13. Tested statistically these differences in both field categories are far too small to achieve the 5% level of significance ($P \gg 0.05$, Wilcoxon, one-tailed test). It can thus be inferred that the frequency differences present in the main experiment (16 - 7 per 400 000) do not affect the number of trials with correct reports of peripheral words.

It can thus be concluded that a positive relationship between associativity and the number of peripheral words reported exists.

The second question posed in the introduction was whether the RT to the central word is affected by the associativity between the words in the stimulus field and, if so, whether this is influenced by the correct identification of peripheral words.

For each subject RTs to S_c in fields of high and low associativity and for trials with and without (correct) report of any S_p were computed. The respective means are shown in Table II.

Table II: The mean RTs to the central word in fields of high and low associativity for trials with correct report and no report of peripheral words.

Peripheral words	Associativity		Diff.	P
	High	Low		
Unidentified	640	634	6	n.s.
Identified	655	713	-58	<.01
Diff.	-15	-79	-64	-
P	n.s.	<.05	≈.05	-

Within-subject differences are tested with the Wilcoxon matched-pairs signed-ranks test (two-tailed). Time in ms.

Table II shows a significant difference in the RT to S_c between fields of high and of low associativity when at least one S_p is identified. Furthermore, a significant difference is found for fields of low associativity between the RT to S_c with and without an identified S_p . (The non-significant differences indicated are well above the 10% level).

As for the category of non-associative fields, the mean RT to S_c was 634 ms when no S_p was identified. No subject, however, ever correctly identified a peripheral group of letters in these fields.

Thus, the observer, in fixating the central word, needs less time to identify and report this word when its meaning is strongly rather than weakly associated with the meanings of the peripheral words, i.e. provided at least one of these peripheral words is also identified.

Discussion

Before an interpretation of the results is undertaken, some pertinent points should be considered. Firstly, in following the in-

structions the subject fixates a mark on the screen during stimulus presentation. The central stimulus, S_C , appears directly upon this mark. The visual angle covering S_C is so small that no eye-movement is needed for reading the word. The minor differences in word-length are negligible (Klintman, 1968). In the instruction it is also stated that the subject's task is not to attempt to identify the peripheral words, but that any such word, if identified, should be reported. It will be assumed that the majority of the subjects followed the instruction. (Some extremely long or missing reactions to S_C may indeed have originated, however, from incorrect fixations).

Secondly, the ease of identification of the peripheral words varied during the experiment. This phenomenon was expected and its effect controlled by proper balancing of the stimulus conditions. These conditions may be said to be marginal in relation to the identification of the words: the ease of identifying the words is thus sensitive to minor variations in what is generally termed attention.

As a starting point for interpretation the results, the study referred to above (Klintman, 1969) which showed identification of a stimulus (S_2) to take less time if it is preceded by a strongly than by a weakly associated initial stimulus (S_1) can be considered. It is possible that this facilitative interference is also effective in decreasing the amount of stimulation necessary for S_2 to be identified, that is, in lowering the limen for its correct identification. If this same reasoning is applied to the spatial stimulus fields in this experiment, cognitive interaction may be expected to have occurred between the two processes P_C (the cognitive activity initiated by S_C and developing in the direction of complete identification of this stimulus) and P_P (the

respective cognitive activity initiated by P_p), provided that some phases of them are parallel in time.

If this is indeed the case, two kinds of interference would seem to be present: (a) inhibitive, and (b) facilitative. The inhibitive interference is revealed in the fact that the RT to S_c is longer when an S_p is also identified. This is best seen in the fields of low associativity. Here, identifying an S_p increases the RT to S_c . This may well be a function of the increased amount of information made conscious when both S_c and an S_p are identified (cf. Hyman, 1953). In such cases, the S_p is 'forced' upon the individual as a consequence of his relatively high perceptual readiness (attention) at the time of stimulation. This kind of 'compulsion' is the same in principle as that experienced when an object is shown to our open eyes or when someone speaks to us within earshot: if we are ready, we must perceive.

The facilitative interference is apparent in the fields with high associativity: (1) If its effect is in the direction $P_c \rightarrow P_p$, as suggested above, it tends to lower the limen for correct identification of S_p (the number of trials in which an S_p is reported increases). This means that if under a rather high degree of attention an S_p is otherwise unidentifiable but is just below the limen for identification (i.e., only a small increment in stimulus strength would be needed for S_p to be identified) this stimulus is now elevated above the threshold (facilitative interference $P_c \rightarrow P_p$) and can thus be reported. (2) If its effect is in the direction $P_p \rightarrow P_c$ it produces a decrease in the RT to S_c when an S_p is also identified. Its presence is implied by the fact that in the fields with high associativity no difference in RT is found between trials with and trials without an identified S_p . That is, the increase in the RT to S_c in fields with low associativity, ascribed above

to a change in the amount of information, is compensated for in fields of high associativity (facilitative interference with the direction $P_p \rightarrow P_c$). It follows that this type of interference must occur in an advanced phase of P_p . (The RT to S_c is not affected by field associativity when no S_p is identified). It seems possible that this interference is similar in principle to that observed in sequential stimulation designs (above).

Finally, it should be noted that a certain degree of facilitative interaction may have been present between the peripheral words of the high associativity fields. However, since S_c is perceptually dominating (due to the instruction and the nature of the task) it would seem justified to assume that this stimulus is also the main source of interference with these words.

The interpretation just presented in a brief way is concerned with cognitive phenomena which may be in progress when one perceives and reacts to a complex visual stimulus field. Emphasis here has been laid upon the temporal aspect of the interaction between the parts of the field during the process of stimulus identification.

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*Cognitive Activity in the Afterphase
of Perception as Related to Spiral
Aftereffect Duration*

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A b s t r a c t. - The duration of the kinetic aftereffect following fixation of a rotating spiral figure (SAE) was found to be related to the cognitive interference of the meaning of a perceived stimulus (S_1) with the reaction time (RT) needed for identifying subsequent stimulus (S_2). The hypothesis that inter-individual differences in SAE and in the "cognitive aftereffect" of perceiving S_1 are dependent on similar regulatory functions was supported. A possible functional model of the two phenomena is discussed.

Earlier experiments by the author using sequences of two different meaningful stimuli (S_1 and S_2) have demonstrated how the reaction time (RT) to S_2 is affected by the meaning of S_1 . This phenomenon is referred to as cognitive interference in a contrast reaction (Klintman, 1969, 1970). The RT to S_2 is thus a function not only of S_2 but also of the specific cognitive activity going on after the identification of S_1 and still continuing at the onset of S_2 . This cognitive afterphase activity can be seen as a "cognitive aftereffect" or cognitive residual of the perception of S_1 . If the time interval between the two stimuli is sufficiently short, the S_2 must be identified relative to this aftereffect.

In the two experiments referred to above it was shown that the average RT to S_2 (RT_2) in a group of subjects was shorter when the associative bond between S_1 and S_2 was strong than when it was weak, and that the corresponding average was shorter when S_2 was congruent with S_1 (S_1 = name of the color, S_2 = a colored surface) than when it was incongruent. The contrast effect appeared to be most pronounced at the beginning of the experiment, leveling off during the later phases.

Since an adequate description of these phenomena requires consideration of inter-individual variation, the question can be raised as to whether such variation in the dependent RT measures might be partially a function of individual styles in

handling the stimulus sequences. The attempt will be made here to answer this question.

Since a cognitive aftereffect seems to be operating in contrast reactions of this type, it seemed logical to consider the relationship between these and visual aftereffects, i.e. the aftereffects of a perceived stimulus pattern, whether moving or stationary.

Andersson (1971) has demonstrated persistent individual differences in the perception of the spiral aftereffect (SAE). These have been linked to basic differences in personality (see below). The present study will consider the problem of whether individual differences in the SAE can be related to differences in cognitive aftereffect as measured by variations in the RT to S_2 as a function of the meaning of S_1 (cf. above).

M e t h o d

Reaction-time (RT) series

a. Material. The stimulus material consisted of slide projections of printed color-names (S_1), (RÖD, GRÖN, GUL, BLÅ / red, green, yellow, blue) and a rectangular colored surface (S_2), one for each of these hues. When a word and a colored surface were exposed simultaneously the word was seen as closely fitted within the surface. When projected on the screen, the words were 35 mm in height and the colored surface 45 mm. Both the colored surface and the longest word were 100 mm in length. The words were printed in capital letters of colorless gray. The brightness and saturation of the colors were chosen so as to facilitate color identification. The brightness of the words was sufficient for them to be easily read.

b. Apparatus and stimuli. Two slide projectors equipped with fast-operating hydrogen bulbs were fed with (triggered by) pairs

of impulses from an electric timer. An electric chronometer (mark FAVAG, calibrated 1/100 sec.) was connected parallel with one of the projectors. A voice key (a microphone which closed a stopping-circuit in the chronometer via amplifier and relay when sound was received) was placed in front of the subject. The projectors were loaded with two stimuli: a colored surface (S_2) and a color name (S_1), respectively. At each presentation a sequence of these stimuli was shown. The chronometer measured the time between the exposure of S_2 and the subject's verbal reaction to (identification of) this stimulus. S_1 was exposed for 25 ms and S_2 for 85 ms. The time interval between the two stimuli in a sequence was 650 ms. The subject was seated in front of a ground-glass screen at a distance of 170 cm, the projectors being placed 120 cm behind the screen.

c. Design. The experiment began by presentation to the subject of a warm-up series where RT to single color surfaces was measured. This was followed by the main experiment, involving a total of 64 double stimulus presentations. Under each of two S_1 - S_2 time interval conditions (650 ms and 30 ms)¹⁾ the series included 16 congruent pairs (surface S_2 of the same color as that indicated by color name S_1) and 16 incongruent pairs (surface S_2 being one of the three colors different from that indicated by the color name S_1). It was assumed that in general the associative relation between a color and its name is stronger than that between a color and the name of a different color. (The validity of this assumption was sustained in an earlier study using the same stimuli (Klintman, 1970)).

The pairs within both the congruent and the incongruent categories were balanced with regard to specific colors and color names. The total series was divided into 4 equal parts, the initial one being of special interest in this study. Each of

¹⁾ The study presented here concerns only the condition 650 ms.

the four parts contained 4 congruent and 4 incongruent pairs under each of the two S_1 - S_2 time interval conditions. Within these limits the stimulus pairs were distributed in an unsystematic fashion with regard to congruity, time interval and colors, in order to avoid undue stimulus anticipation by the subjects. In matters of detail, the stimulus distribution was different in each of the four segments of the total series.

The time interval between the stimulus pairs was about 15 seconds.

The basic RT-measure was the difference (D) between the subject's median RT for naming the color of the surface (S_2) under the incongruent (C-) and congruent (C+) stimulus conditions in the initial part of the series.

d. Instruction. The following instructions were given the subjects orally: "Before the main experiment we shall present you a series of single-color surfaces. Your task will be to name the color of each surface as quickly as possible". - After a few practice trials: "Now let us proceed to the main experiment. The purpose of the experiment is to measure your reaction speed to colors. That is, we shall try to determine how fast you can name a color - red, green, yellow or blue - exposed on this screen just as before. In each display, however, you will be presented first with a color name and then with the colored surface. The time interval between the color name and the colored surface may be well over a half-second at the one extreme or so brief as to make the display of name and surface seem practically simultaneous at the other extreme. Frequently, the meanings of color and word do not agree. For example, the color may be red and the word "yellow", or the color green and the word "blue", etc., while in other instances the two may agree, the word being the name of the color. Your task will be to name the color as quickly as possible, and after that to report the word which preceded presentation of the colored surface. It is important that you react as fast as possible. Try not to think about any specific color before the display is shown. Speak loud and clear into the microphone".

e. Subjects. The subjects used here and in the spiral after-

effect experiment (to be described) were 30 female and 15 male students of psychology (first year university course), aged 19 to 25 years. Six out of the original group of 51 subjects were excluded from the experiment due to self-reported deficient color vision, or because of their using spectacles with colored glass.

Measuring the spiral aftereffect (SAE). The apparatus used for measuring the SAE was identical with the type previously used by Andersson (e.g. 1969). The subject was first asked to fixate a rotating spiral figure for a period of 55 seconds. The spiral black and on a white background, was designed to give the impression of moving inwards when rotated. Following fixation, the spiral was replaced by a stationary circle, likewise black on a white background. The subject was to signal as soon as he noticed any changes in the perception of the circle, such as contraction or expansion. Typically the spiral aftereffect obtained with the present procedure is associated with perceived expansion of the circle. One fixation period plus one period of perceived SAE constitute a trial. Ten such trials were given in immediate succession, the duration of each SAE period being scored. On the basis of these ten measurements the following parameters were computed: The initial level (iL, the mean duration of the SAE during the first two trials), the final level (fL, the mean duration of the SAE during the last two trials), and the regression (R, a function of the linear regression of SAE durations over the ten trials).

According to Andersson the perception of the spiral aftereffect and the stationary circle, respectively, can be understood as representing two opposite types of perception: the intraceptive and the extraceptive or stimulus-proximate ones. The degree of intraceptive as compared to extraceptive perception, the former being reflected in the SAE duration, is

taken as an indicator of the general tendency of the individual to facilitate intraceptive events at the expense of extraceptive ones. The relation between these two ways of perceiving is viewed as a sign of the degree of reality testing employed by the individual (Andersson, 1971).

Classification of individuals on the basis of the parameters iL , fL , and R have been meaningfully related to personality via specific types of behavior like social-emotional adjustment, the regulation of depressive tendencies, social dependence, and also accident-proneness in young car drivers (Andersson, Nilsson, Ruuth & Smith, 1972).

R e s u l t s

In the RT part of this study a group median of $MD_D = +7$ ms was obtained; this represented the median of the individual differences between the RT to S_2 in incongruent and in congruent stimulus pairs in the initial series (8 measurements). Throughout statistical treatment of the data a cut-off point at $D = Md_{C-} - Md_{C+} = 0$ was used. Thus a 'high' group of subjects with $D > 0$ and a 'low' group with $D < 0$ are obtained. This limiting value is of special interest theoretically, and will be further treated in the discussion. A $D > 0$ means that the individual's median RT for identifying the colored surface S_2 is longer in incongruent than in congruent pairs, while in the case of $D < 0$ the reverse is true.

In the SAE part, the limiting values for high and low group subjects as regards fL and R were those frequently employed by Andersson ($fL = 16.5$ sec. / P_{75} / and $fL = 7.5$ sec. / P_{25} /, $R > 0$ and $R < 0$, respectively). As for iL , the only standard value reported by Andersson is a median of 13 sec. This value as well as quartile divisions were used here. The results were tested with the Fisher exact probability test (one-sided).

Table 1. The relationship between D in the RT part and iL in the SAE part; (a) standard median split, (b) quartile divisions (extreme groups).

(a)	D > 0	D < 0	(b)	D > 0	D < 0
iL > MD	13	7	iL > P ₇₅	9	1
iL < MD	8	16	iL < P ₂₅	4	7
P = .0361			P = .0170		

Table 2. The relationship between D in the RT part and fL in the SAE part, using the standard quartile divisions.

	D > 0	D < 0
fL > P ₇₅	6	1
fL < P ₂₅	7	12
P = .0365		

Tables 1 and 2 show a positive relationship between D and SAE duration. If we reduce the variation in fL to $P_{25} < fL < P_{75}$, iL differentiates D as shown in Table 3a. Table 3b gives the corresponding case for fL when the variation in iL is reduced.

Table 3. The relationship between D in the RT series and (a) iL when keeping fL at $P_{25} < fL < P_{75}$, and (b) fL with iL at $P_{25} < iL < P_{75}$.

(a)	D > 0	D < 0	(b)	D > 0	D < 0
iL > P ₇₅	4	0	fL > P ₇₅	5	0
iL < P ₂₅	0	3	fL < P ₂₅	1	4
P = .0286			P = .0238		

The differences evident in Table 3 indicate that both iL and fL differentiate D in the RT part. This is also the case when the standard SAE groupings are used: HR (hypersensitive, fL high, iL high, $R > 0$), SE (sensitive, iL low, fL medium, $R > 0$), MS (mediosensitive, iL medium, fL medium, $R \approx 0$), DE (desensitive, iL high, fL medium, $R < 0$), and HO (hypo-sensitive, fL low, iL low, $R < 0$), as defined in Andersson's model. Table 4 shows how these groups are differentiated in terms of D.

Table 4. The SAE groups related to D: H = high quartile group, L = low quartile group, M = intermediate group.

iL	fL	R	SAE group	D > 0	D < 0
H	H	> 0	HR	6	0
L	M	> 0	SE	0	3
M	M	≈ 0	MS	1	2
H	M	< 0	DE	4	0
L	L	< 0	HO	1	5

Table 5. The relationship between D and (a) SE and DE, (b) HR and HO, and (c) HR + DE and SE + HO in the SAE test.

(a)			(b)		
	D > 0	D < 0		D > 0	D < 0
SE	0	3	HR	6	0
DE	4	0	HO	1	5
P = .0286			P = .0076		
(c)					
	D > 0	D < 0			
HR + DE	10	0			
SE + HO	1	8			
P = .0001					

As can be seen, D is a function of both the initial and final duration of the aftereffect, whereas regression (R) bears no meaningful relationship to D in this material.

D i s c u s s i o n

The results indicate a relationship between aftereffect duration in the SAE experiment and the parameter D in the RT series, subjects with short SAE durations tending towards values of $D < 0$ and those with long SAE durations towards $D > 0$.

Regarding an interpretation of the relationship which was found between the SAE and RT variables, the question arises as to whether this might simply be caused by an afterimage of S_1 in the RT series. The possibility that a positive afterimage of S_1 is present at the time S_2 is exposed (via visual persistence, VP) seems unlikely: the observed maximum duration of the VP is about 400 ms (as compared to the interval 650 ms between S_1 and S_2 in this experiment). Furthermore, the VP decreases with increased stimulus intensity (Dixon & Hammond, 1972) and in the present experiment the intensity of S_1 was chosen relatively high in order to facilitate readability. The other possibility to consider is that a negative afterimage of S_1 might have been responsible for the results obtained. A relationship between SAE duration and negative afterimages has been reported by Smith, Fries & Andersson, (1969). However, such afterimages rapidly lose the original contours of the fixation stimulus. When words are used their afterimages become blurred and poorly readable. Regarding the possible consequences which a negative afterimage could have upon interference with S_2 , it is true that a strong afterimage (if present and also readable) could cause cognitive interference with S_2 at the time of exposure of that stimulus. This could then result in a shorter RT to S_2 in congruent than in incongruent pairs, i.e. in $D > 0$. However, if the afterimage

of S_1 were weak, sporadic or non-existent at the onset of S_2 , then it could scarcely cause much cognitive interference. Any consequence it might have would be to reduce D to zero or to a small positive value, but not to produce a D with a negative sign. Yet the results yield a difference of this very sort; subjects with short SAE duration display a preponderance of negative D s, while those with long SAE duration tend to show positive D -values. This is difficult to explain solely on the basis of a negative afterimage hypothesis. In addition, in an earlier study (Klintman, 1970), where S_1 was a color surface and S_2 a color name, no interference from a negative afterimage of S_1 with the identification of S_2 could be observed. On the contrary, cognitive interference caused by the 'positive' meaning of S_1 was obtained.

It can therefore be concluded that part of the variation in D is the function of a cognitive aftereffect of S_1 : subjects with suppressive tendencies in the SAE test also suppress the cognitive residual of the perception of S_1 in the RT part of the experiment.

At the time of S_2 this selective inhibition hampers reactuation of the meaning of S_1 , i.e. it delays re-initiation of cognitive activity specific to the meaning of S_1 . Therefore, if S_1 and S_2 are congruent (alike in meaning), the inhibition causes an increase in the RT for identifying S_2 as compared to the case of incongruence: D thus becomes < 0 . Conversely, in subjects with SAE facilitation a pronounced cognitive interference between the meanings of S_1 and S_2 occurs since the cognitive activity initiated by S_1 overlaps the phase of identifying S_2 . Interference here becomes positive in congruent pairs and negative in incongruent ones: D thus becomes > 0 .

So far, the results indicate a relationship between spiral

aftereffect duration on the one hand and the direction of the interference with the identification of S_2 by the cognitive aftereffect of S_1 on the other.

The question can now be posed as to whether variation in the SAE level might be dependent on the same regulatory functions as those controlling the cognitive aftereffect in the RT series. In an attempt to find an answer to this question we will first sketch a simple model for the identification and reporting of a meaningful stimulus, such as a word (Figure 1). The Figure is limited to a few aspects of the cognition and identification of well-known supraliminal stimuli. It depicts that part of the de-coding process pertaining to the identification of the symbolic meaning of S_1 . This de-coding process or cognition is conceived as continuing until identification of the part of the meaning relevant to the final report has occurred. It is postulated that the verbal response conditioned by the instructions is dependent upon and preceded by this de-coding process. This would mean that interference which caused temporal changes in the latter would also cause changes in the verbal RT to identifying (naming) the stimulus (S_2).

In these terms Figure 2 shows how D in the RT series can be seen as having been affected by the cognitive interference. If the relevant meanings of S_1 and S_2 are alike (e.g. "red"), then a selective inhibition of the cognitive residual of S_1 (via a cognitive regulatory function, CRF) would cause inhibition in the cognition of S_2 , (likewise "red") to occur also, thus increasing the RT to this stimulus. In other words, the specific inhibition of a given cognitive activity can be observed in terms of an increase in the difficulty of re-initiating this activity upon repeated stimulation. In Figure 2 it can be seen that "cognition of S_2 " is a function not only

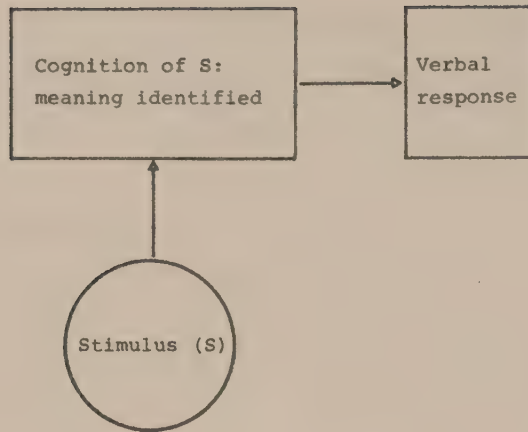


Figure 1. Process diagram of identification and verbal report of a stimulus word.

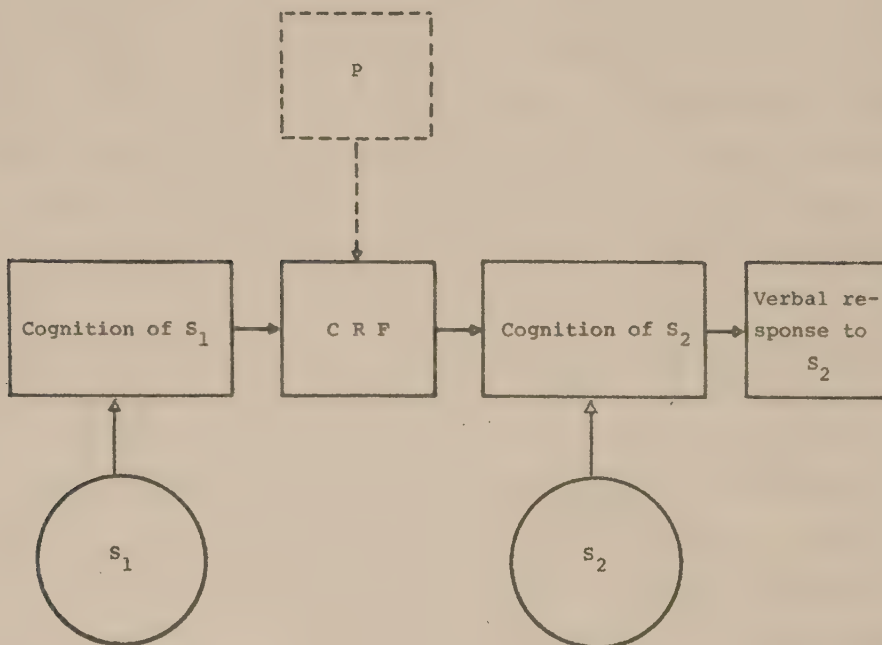


Figure 2. Principles of cognitive interference $S_1 \rightarrow S_2$. The relevant meanings of the two stimuli are assumed¹ to be equal. A cognitive regulatory function (CRF), controlled by system P, selectively facilitates or inhibits the contents of the cognitive residual of stimulus S₁, thereby interfering with the cognition of stimulus S₂.

of S_2 itself but also of the regulation of the cognitive residual of S_1 . The increase in the RT to S_2 here should be seen as in contrast to the case of incongruent pairs, where CRF inhibition does not impinge upon the meaning relevant to identifying S_2 and thus does not affect RT. Conversely, if the CRF operates in a facilitative manner, the identification of S_2 becomes easier in congruent than in incongruent pairs since here facilitation of the cognitive residual interferes with the identification of S_2 .

The box with a dashed line in Figure 2 suggests the possibility of the CRF being regulated by a higher organizational system, P.

It seems plausible that the same general principles are applicable in an interpretation of SAE regulation. In Figure 3a these principles are: (1) cognition of the fixation stimulus (in the Figure this is suggested by various verbal concepts central to the stimulus meaning); (2) regulation by the CRF (and P) of the cognitive residual of stimulus S_1 (this cognitive residual is conceived of as intraceptive in Andersson's terms; its regulation included inhibition (as in Figure 3a), or facilitation, of the meaning of the stimulus figure. The specific content of the inhibition has been indicated by negation of the part-meanings mentioned above. Insofar as the stimulus figure and the primary SAE share the same meaning, or partial meaning, cognition of the SAE will be affected by the CRF in the afterphase of perceiving the stimulus figure); (3) inhibition (facilitation) of the re-cognition components of meaning controlled by the CRF, and thus interference with the cognition of the primary SAE pattern; (4) interference from the cognition of S_2 (the stationary circle).

In the interpretation here the principles used earlier in de-

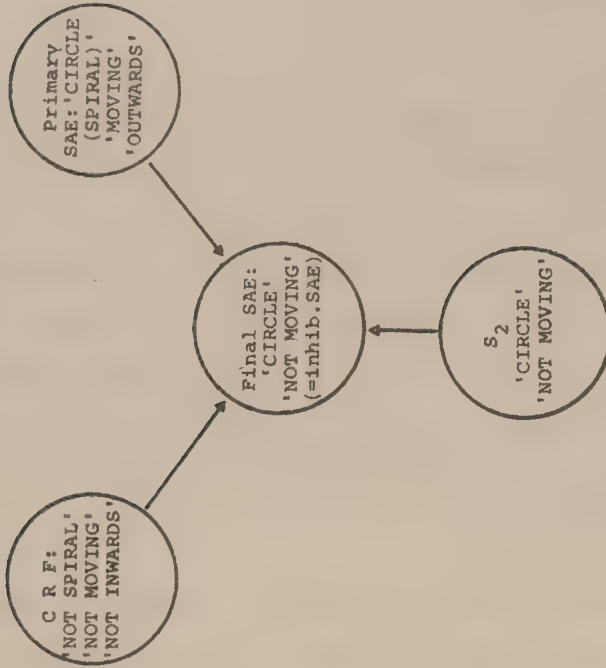


Figure 3b. The final SAE as a function of cognitive interference between the CRF (cognitive regulatory function) acting on the cognitive residual of the moving fixation figure S_1 , cognition of the primary (physiologically conditioned) SAE, and cognition of the circle S_2 .

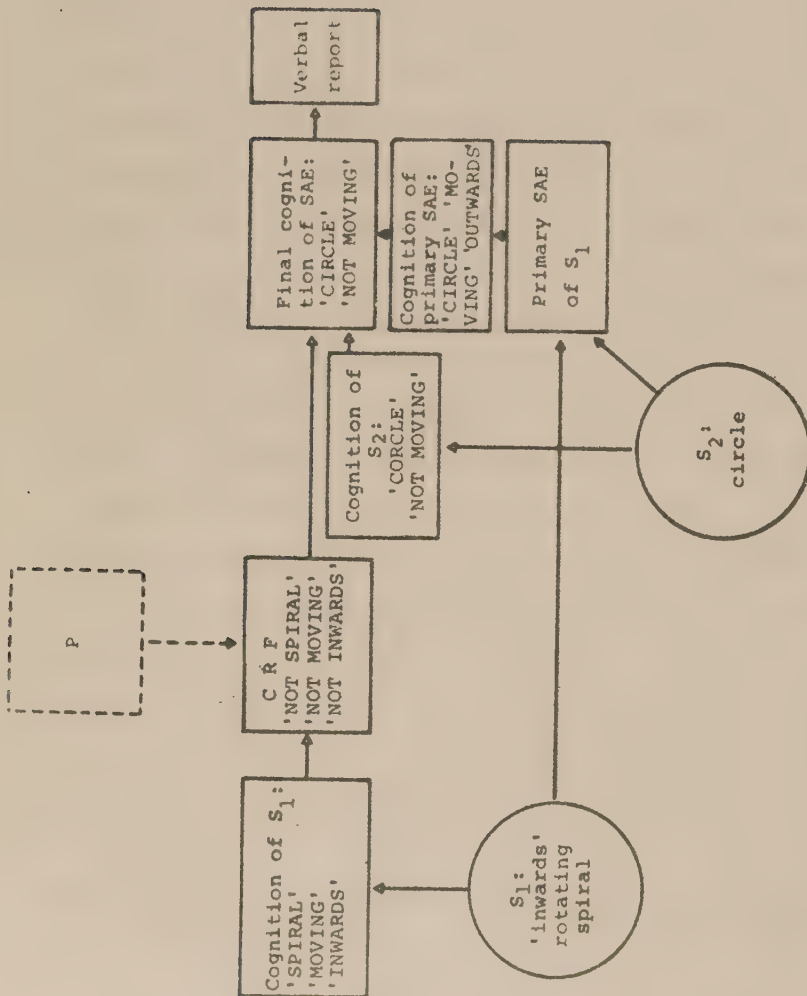


Figure 3a. Principles of regulation of the SAE. The figure indicates the modification of the cognitive residual of the fixation figure (in this case inhibition, the inhibitive function being denoted by the negation of the meaning of S_1) by a cognitive regulatory function (CRF). The ongoing selective inhibition interferes with cognition of the primary (physiologically conditioned) SAE ("circle", "moving", "out"). At the same time a competing tendency toward cognition of the stationary circle (S_2) is present. The net result of this three-factor interference (see also figure 3b) is inhibition of full cognition of the primary SAE. The CRF is controlled by the higher system P.

scribing cognitive interference within the RT series are applied unchanged to SAE regulation. It should be noted that the regulating function (CRF) is not conceived as acting primarily on the SAE but rather on the cognitive residual of the positive fixation figure. If the latter contains cognitive components which are necessary for the cognition of the SAE (e.g., "spiral", "moving"), then cognitive interference with the aftereffect will ensue. Figure 3b illustrates schematically the case of cognitive interference between the CRF, cognition of the circle, and cognition of the primary (invariable) SAE. It is presumed that this interference leads to inhibition of the SAE (the central circle). The Figure applies to the inhibitive case. The facilitative case can be described in terms of the negation of the partial meanings in the CRF circle.

In this model, part of the personality-related variation in the SAE phenomenon is contingent on the cognition of the meaning of the fixation figure S_1 . In the afterphase of perception this cognition is subjected to regulation by system P via the CRF. The fact that the functions responsible for this regulation are acting at a high cognitive level and at a relatively early phase of the SAE experiment points to the possibility that the regulation may be sensitive to interference caused by variation in some of the experimental conditions: the personality-related variation in the SAE phenomenon may be susceptible to interfering cognitive activity during the fixation period and immediately thereafter, brought about by some irrelevant stimulation effectively diverting the subject's attention from the fixation figure. In principle, suppressing (by means of averted attention) the cognition of the fixation figure would tend to neutralize the CRF, since the latter function would lack relevant cognitive material as far as the SAE is concerned. This being the case, cognition of the primary (invariable) SAE would take place without much modification

from the CRF. This would tend to cancel out much of the personality-related variation in the SAE duration usually found.

The concept of inhibition has been used earlier as a basis for explaining inter-individual differences in SAE duration. Eysenck, Holland & Trouton (1957) (see also Holland, 1965) consider personality-related differences in the phenomenon to be a consequence of variations in the "damping" of the neural activity following prolonged visual stimulation. They assume this damping mechanism to be active during the influence of depressant drugs. They view variations in SAE duration between "extraverts" and "introverts" as being dependent upon differences in the excitation of the "neural substrate" after extended visual stimulation. Although no reference is made here to the possible importance of higher associative processes, these authors apparently assume regulation of the SAE to take place in relative independence of such processes. As a consequence, factors such as interfering cognitive activity, diverted attention, interpretation of the meaning of the stimulus figure, etc., would tend to have no influence on the phenomenon.

The present study, however, suggests that the personality-related variation in SAE duration occurs through the interpretation by the subject of the symbolic aspect of the stimulus, i.e. through the de-coding of its meaning. Support is thus provided here for the hypothesis that this variation and the related variation in the parameter D are both directed by the same cognitive regulatory function, the latter receiving its instructions from a superior system P.

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Reaktionstid som Indikator för Subliminalitet

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Reaktionstid som indikator för subliminalitet.

Kontroversiell inom varseblivningspsykologin har länge varit frågan om s.k. subliminal perception: I en rad undersökningar under senare decennier har hävdats, att under vissa betingelser, t.ex. prematurt avbrytande av perceptionsprocessen, eller vid lågintensiv stimulering, varseblivningen s.a.s. inte når upp till medveten nivå, men att den dock röjer sin existens genom karakteristisk påverkan av annat beteende (Golddiamond, 1958; Dixon, 1971).

Som exempel på en metodik för påvisande av subliminal perception kan nämnas meta-kontrasttekniken: Två stimuli, S_a och S_b , presenteras takistoskopiskt i snabb följd, den första ljussvagare och med kortare duration än den andra. Därvid kan fenomenet inträffa, att försökspersonen (fp) efter stimuluspresentationen rapporterar sig ha varseblivit endast S_b . Emellertid tyder ej sällan fp's beskrivning av S_b på att meningen hos S_a påverkat upplevandet av S_b (Smith & Henriksson, 1955; Farné, 1963). Detta har tolkats som stöd för hypotesen om icke-medveten perception.

Kritiken av begreppet subliminal perception har bl.a. påpekat, att fråvaron av spontan rapport av S_a ej nödvändigtvis betyder att denna eller delar av denna ej upplevts medvetet. Varje individ har ett "kriterium för rapportering" som kan sättas högt eller lågt. Gränsen är beroende av en beslutsprocess, vid vilken fp "maximerar konsekvenserna av responsen"; han kan därvid t.ex. taga hänsyn till vad han tror försöksledaren (fl) önskar eller förväntar sig (Wiener, 1960).

I ett av sina experiment (1960) låter Wiener efter försöket fpp skatta hur säkra de är på att ha sett S_a , varvid denna specificeras. Skattningarna visar ett positivt samband med styrkan av den i rapporten av S_b observerade effekten av S_a . Experimentet anses visa hur bakom utebliven spontanrapport medveten perception under kriteriet för spontan rapportering kan dölja sig. Det hävdas, att fp kan ha varseblivit delar av S_a , vilka varit tillräckliga för en generalisering till hela S_a . (I det aktuella fallet var S_b en tvåtydig geometrisk figur och S_a ordet för det ena tolkningsalternativet.)

Argumentet att sådana "partial cues" är verksamma vid subliminal perception bemötes i en undersökning där man ej kan påvisa en ökning i effekten av subliminal S_a som funktion av exponeringstiden (Smith et al., 1959).

Annan kritik har riktat sig mot bestämningen av tröskelvärdet för subliminalitet. Denna sker vanligen före huvudförsökets början, varvid ofta "provstimuli" användes. Kontroll av fluktuationer i tröskelvärdet under försökets gång har ej sällan saknats (Golddiamond, 1958).

Neisser (1963) finner det obestyrkt, att individen skulle kunna korrekt identifiera en komplex subliminal A-stimulus under den korta tiden av mindre än 75 ms som ungefär motsvarar tidsintervallet mellan de två stimuli i meta-kontrastparadigmen. Han pekar på möjligheten att fp letts av experimentets "demand characteristics" mot avgivande av den "rätta" responsen.

Gemensamt för huvuddelen av kritiken är att en "subliminal" stimulus i själva verket helt eller delvis upplevts medvetet av fp vid någon tidpunkt mellan exponeringsögonblicket och rapporten av den supraliminala S_b .

Experiment med subliminal perception har mestadels centrerat kring dess fenomenologiska effekter. Mycket få undersökningar

med meta-kontrastteknik och med reaktionstiden (RT) för S_b såsom indikator för subliminal påverkan från A-stimulus har rapporterats. Fehrer & Raab (1962) och Fehrer & Biederman (1962) visar i olika experiment, att RT för skenrörelse då en svag stimulus maskeras av en starkare på något avstånd från den förra, är densamma som RT för den svagare då denna bjudes ensam. Resultaten tyder på, att den motoriska responsen kan utlösas av en stimulus om vilken fp ej varit medveten.

I föreliggande arbete undersökes effekten av den abstrakta betydelsen hos en enligt gängse kriterier subliminal stimulus, på reaktionstiden för en omedelbart efterföljande supraliminal. Vidare undersöks begreppet "subliminalitet" utifrån den temporala aspekten av perceptions- och responsprocessen.

P r o b l e m s t ä l l n i n g

Undersökningen kan ses som en syntes av två typer av experiment. I den ena (Smith et al., 1959) demonstreras hur en A-stimulus (S_a) ("angry" resp. "happy") kan påverka fp's beskrivning av efterföljande maskeringsstimulus, B-stimulus (S_b), en bild av ett neutralt ansikte. En tolkning av detta resultat är, att icke-medveten varseblivning av S_a under uppbyggandet av den supraliminala perceptionen av S_b interfererat med denna. Därvid har den abstrakta betydelsen av S_a associerats till den centrala bearbetningen av S_b , vilket resulterat i de karakteristiskt färgade rapporterna av den senare.

Den andra typen av experiment gäller kognitiv interferens från meningen hos en första stimulus (S_a) (t.ex. ett ord) med identifiering av en andra stimulus (S_b), presenterad ca $\frac{1}{2}$ sekund senare. Båda stimuli är supraliminala (Klintman, 1969), och RT för S_b användes som beroendemått.

Föreliggande arbete kombinerar de båda teknikerna: Meta-kontrastmaskering av S_a tillämpas, medan RT för S_b användes som indikator på interferens från subliminal perception av S_a med tiden för

identifiering av S_b .

Valet av stimuli var avsett att skapa två kontrasterande betingelser: En 'faciliterande' och en 'inhiberande' vad avser lättheten att identifiera S_b . För detta ändamål användes kombinationer av färger och färgord. S_a är ett färgord och S_b en färgyta, vars färg överensstämmer (kongruent betingelse) eller ej överensstämmer (inkongruent betingelse) med den färg S_a benämner.

Hypotes 1 gällde undersökning av effekten på RT för S_b av kvalitativa karakteristika hos S_a :

Om två visuella stimuli (S_a och S_b) presenteras i följd så att S_a maskeras av S_b , samt om betydelsen av S_a är inkongruent med betydelsen av S_b , kommer den icke-medvetna perceptionen av S_a att medföra interferens med identifieringen av S_b . Interferensen kommer att fördröja identifieringen av S_b i jämförelse med kontrollbetingelsen, vid vilken en med S_b till sin betydelse kongruent S_a presenteras. Fördröjningen i identifieringen av S_b kan observeras i skillnaden i RT för S_b under de båda betingelserna.

Hypotes 2 gällde effekten av kvantitativa karakteristika (det temporala förloppet) hos identifiering av en subliminal kontra en supraliminal S_a på RT för S_b :

RT för S_b är längre om denna stimulus föregås av en supraliminal än vid subliminal S_a .

Denna senare hypotes vilade på antagandet, att subliminal identifiering ianspråktager en mindre del av den informationsbearbetande centrala kapaciteten än supraliminal. Det är känt, att successiv stimulering med krav på maximal responshastighet för den andra av två supraliminala stimuli p.g.a. kapacitetsbegränsning avsevärt påverkas av närvaron av den första (se Diskussion).

Metod

Apparatur. Två stillbildsprojektorer med vätgaslampor med kort tänd- och släcktid matades med parvisa impulser från en elektromekanisk tidgivare. Parallellt med den ena projektorn var kopplad en elektrisk kronometer, vilken automatiskt igångsattes då projektorn mottog en impuls. Framför fp var placerad en mikrofon, som via förstärkare och relä slöt en stoppkrets i kronometern då fp avgav ljud. Den ena projektorn var laddad med en bildfärg, den andra med namnet på en färg. Vid varje presentationstillfälle exponerades en sekvens $S_a S_b$. Kronometern var kopplad till färgprojektorn och mätte tiden mellan presentationen av färgen och fp's benämning av densamma. Fp var placerad 150 cm framför en halvgenomskinlig skärm, de två projektorerna 150 cm bakom denna. Rummet hölls svagt belyst under experimentet.

Stimuli. S_a utgjordes av namnet på endera av de fyra färgerna grön, röd, gul, blå. Texten i blockbokstäver var vit (ljustext). Varje ord hade på skärmen en längd av ca 8 cm och en höjd av 4 cm. Exponeringstiden för S_a var 10 ms med en intensitet sådan, att ordet nätt och jämt kunde läsas då det exponerades ensamt vid en utproving före experimentet. S_b bestod av en färgyta som var grön, röd, gul eller blå, 10 x 10 cm då den projicerades på skärmen. Ljushetsgrad och färgmättnad var avpassade så att färgerna skulle vara lätta att identifiera. Exponeringstiden för S_b var 450 ms. På skärmen föll S_a på en yta mitt i projektionsytan för S_b . Denna var markerad med en fixerpunkt.

Försökspersoner. Fpp var 22 kvinnliga studenter från andra årskursen i psykologi. Deras ålder var 19 - 25 år. En var dock något över 30. En av personerna genomgick experimentet 4 gånger (olika dagar), varför 25 fp-sessioner erhöles.

Instruktion. Fp placerades i en stol framför skärmen och erhöles följande instruktion: "Vi kommer att exponera olika färger - en åt gången - på skärmen här, röd, gul, grön eller blå. Din uppgift är att benämna färgen så snabbt som möjligt efter att den exponerats. Därefter skall du rapportera om du tyckte dig också se något annat än själva färgytan, linjemönster, ljus e.d. Jag säger 'nu' någon sekund före varje exponering, och det är lämpligt att du låter blicken vandra mellan presentationerna och åter fixerar skärmen när jag säger 'nu' nästa gång. Om du råkat blinka eller ej varit redo, meddela detta efteråt. Försök låta bli att tänka på något speciell färg före exponeringen. Några frågor? - Vi börjar med några provexponeringar". (Därefter:) "Då börjar huvudförsöket".

Procedur. Försöket inleddes med en provserie, som bestod av ett antal sekvenser $S_a S_b$. Intervallet mellan sekvenserna var ca 8 sek., liksom under huvudförsöket. Intervallet $S_a - S_b$ varierades från 10 ms och uppåt i steg om 10 ms till dess ett intervall uppnåts, vid vilket fp kunde rapportera någonting utöver färgytan. Därefter mins-

kades åter intervallet i steg om 10 ms tills åter endast färgytan rapporterades under tre successiva presentationer. Detta senare intervall antogs medföra maskering av S_a och fick tjäna som utgångspunkt för huvudexperimentet. Förfarandet resulterade i ett intervall av 90 ms för 1 fpp, 50 ms för 13 fpp, 40 ms för 8 fpp och 30 ms för 3 fpp. Om under huvudförsökets gång någonting utöver färgytan rapporterades, avkortades intervallet med 10 ms i följande exponeringar tills sådan rapport uteblev. Endast mätningar åtföljda av rena färgrapporter togs med under betingelsen 'subliminal'. I huvudserien avgav varje fp 100 reaktioner. Var och en av de möjliga ord/färgkombinationerna presenterades 5 gånger, en gång inom varje femtedel av experimenttiden. Sekvensernas ordningsföljd var oregelbunden inom varje sådan femtedel. Efter försökets slut utfrågades fp om sina erfarenheter under experimentet, speciellt av stimulusmaterial utöver färgytan.

R e s u l t a t

Hypotes 1. Uppgiften var att testa differensen i RT för S_b mellan kongruenta stimulussekvenser ($S_a + S_b$) och inkongruenta sådana $S_a - S_b$). En uppdelning av de i experimentet ingående sekvenserna, deras antal och beteckningar framgår av tabell 1.

Tabell 1. Kongruenta och inkongruenta stimulussekvenser.
Antal presentationer.

Typ A-stimulus	Sekvens S_a/S_b	Antal presentationer/fp
kongruent	grön/grön	5
	röd/röd	5
	blå/blå	5
	gul/gul	
inkongruent	röd, blå, gul/grön	3x5
	grön, blå, gul/röd	3x5
	grön, röd, gul/blå	3x5
	grön, röd, blå/gul	3x5

Då fördelningen av mätvärdena för varje enskild reaktion uppvisade en viss positiv snedhet, har medianen inom varje rad i tabell 1 beräknats. Följaktigen erhöles fyra "kongruenta" och fyra "inkongruenta" medianer för varje fp. Dessa medianer fick ingå som cellvärden i variansanalys av resultatet med avseende på faktorerna "typ A-stimulus" och "försökspersoner" (tabell 2).

Tabell 2. Sammanfattning av variansanalys av skillnaden i RT för S_b mellan kongruenta och inkongruenta stimulussekvenser (typ A-stimulus).

Varianskälla	Kvadratsumma	Fg	Variansuppsk.	F	P
Individer (A)	6521.9	24	271.75		
Typ A-stimulus (B)	152.3	1	153.30	6.70	<.05
Interaktion (AxB)	545.2	24	22.72	.36	e.s.
Inom celler	9363.2	150	62.42		

Resultatet bekräftar hypotesen på 5%-nivån. Medelvärde för kongruenta sekvenser är 565 ms och för inkongruenta 583 ms, dvs. en skillnad av 18 ms i förväntad riktning.

Då individuella differenser i felspridning (varierande uppmärksamhet, osäkerhet i responsen, etc.) kunde tänkas föreligga, gjordes ett försök att nedbringa densamma. Då data förelåg från samma fpp i ett annat RT-experiment, kunde gruppen rangordnas m. avs. på felspridning. Data från dem som därvid erhöil värden under medianen för hela gruppen i det oberoende experimentet undersöktes därefter med avseende på hypotes 1, varvid en ny variansanalys utfördes (tabell 3).

Av tabell 3 framgår, att inom-cellvariansen sjunkit från 62.42 (tabell 2) till 21.02, medan den systematiska skillnaden i faktor B blivit mera uttalad ($P < .01$). Medelvärde för kongruenta sekvenser är här 561 ms och för inkongruenta 594 ms, dvs en skillnad av

33 ms i förväntad riktning. Motsvarande värde var 18 ms för hela gruppen. Att minskad felspridning, beräknad utifrån ett annat, oberoende material, leder till ökade signifikanta skillnader i detta experiment, anses ge ytterligare stöd åt hypotesen.

Tabell 3. Sammanfattning av variansanalys av skillnaden i RT för S_b mellan kongruenta och inkongruenta stimulussekvenser (typ A-stimulus) för fpp med låg felspridning i ett oberoende experiment.

Varianskälla	Kvadratsumma	Fg	Variansuppsk.	F	P
Individer (A)	2983.3	11	271.21		
Typ A-stimulus (B)	247.0	1	247.00	10.64	<.01
Interaktion (AxB)	255.4	11	23.22	1.10	e.s.
Inom celler	1513.3	72	21.02		

Effekten av kongruent sekvens jämfört med enkelexponering av S_b gjordes enl. tabell 4. I tabell 5 ges medelvärdena för de tre i experimentet ingående betingelserna.

Tabell 4. Sammanfattning av variansanalys av skillnader i RT för S_b mellan kongruenta stimulussekvenser och enkelexponering av S_b (faktor B).

Varianskälla	Kvadratsumma	Fg	Variansuppsk.	F	P
Individer (A)	6229.9	24	259.58		
Typ A-stimulus (B)	76.9	1	76.90	7.18	<.05
Interaktion (AxB)	256.8	24	10.70	.25	e.s.
Inom celler	6314.0	150	42.09		

Tabell 5. Medelvärden för RT för S_b vid experimentets tre stimulus-betingelser, hela gruppen, vid subliminal resp. ingen S_a .

Stimulus-betingelse	Medelvärde (ms)
S_b (enkelexp.)	553
$S_a + S_b$ (kongr.)	565
$S_a - S_b$ (inkongr.)	583

I tabell 4 framkommer en skillnad, signifikant på 5 %-nivån, mellan betingelserna kongruent S_a och ingen S_a . Medelvärdena är 565 ms resp. 553 ms (jfr tabell 5). Närvaron av A-stimulus, även om denna är kongruent med B-stimulus, tenderar således att fördröja responsen på S_b .

Hypotes 2. Här antogs, att RT för S_b skulle vara längre då denna föregicks av en supraliminal S_a än vid subliminal S_a . Ur tabell 5 erhålls medelvärdet 573 ms för S_b vid subliminal S_a (felspridning 79 ms). Medelvärdet för S_b vid supraliminal (dvs korrekt rapporterad) S_a var 847 ms. Signifikansberäkning av skillnaden mellan dessa medeltal, baserad på inom-individ differenserna, gav för de aktuella personerna $t = 5.09$, $df = 18$, $P < .0005$. Vi finner således att hypotes 2 bekräftas.

D i s k u s s i o n o c h a n a l y s

Resultaten bekräftar i första hand hypotesen att den abstrakta betydelsen hos A-stimulus under de aktuella betingelserna förmår påverka tiden för identifieringen av B-stimulus. Därvid tenderar den senare att förlängas om S_a är inkongruent med S_b i förhållande till fallet vid kongruent S_a . Utebliven rapport av S_a , eller delar därav, trots instruktion och utfrågning, tyder på att fp inte varit medveten om S_a . Denna effekt kan härröra från kognitiv interferens från identifieringen av meningen hos den subliminala S_a med identifieringen av den supraliminala S_b , med åtföljande förändring av RT för den senare.

Samtidigt observeras ytterligare en effekt av subliminal S_a : även då denna är till sin mening kongruent med S_b förekommer en fördröjning av responsen på den senare, jämfört med fallet vid enkelexponering av S_b . Detta förhållande kan förstås om man beaktar, att även en subliminal stimulus tager i anspråk central bearbetningskapacitet, vilket p.g.a. kravet på maximal respons hastighet för S_b blir märkbart i en viss ökning av RT för denna.

Det faktum, att en begränsning i central bearbetningskapacitet föreligger, och att denna övre gräns kan nås genom tillräcklig ökning av inkommande relevant information information per tidsenhet, är av betydelse för tolkningen av de kognitiva förloppen i den här aktuella experimentsituationen.

I diskussionen hittills har "utebliven rapport av S_a " fått tjäna som indikator på subliminalitet. Trots tämligen rigorös kontroll genom instruktion, utprovning av tröskelvärde samt efterutfrågning, är det i sista hand fp 's villighet och förmåga att i efterhand rapportera som är avgörande för validiteten i designationen "subliminal". Jämförelsen enl. hypotes 2, mellan tidsförloppen för identifiering av S_b vid "subliminal" och "supraliminal" S_a , var ett försök att finna ett kriterium för subliminalitet som kunde användas som "korsvalidering" av fp 's rapportering. En närmare analys av denna kvantitativa aspekt av begreppet subliminalitet kan göras på basis av litteraturen rörande experiment med två successiva supraliminala stimuli.

Davis (1959) har visat, att då två supraliminala ljussignaler ges med ett inbördes intervall av 50 ms, varvid fp är instruerad att avge respons på den andra, en förlängning av RT för denna med 90 ms kan observeras.

Elithorn & Lawrence (1955) erhöll vid tidsintervallet 50 ms mellan två visuella stimuli en fördröjning av motorisk RT för

den andra med ca 80 ms. Vid samma intervall, men med visuell/auditiv stimulussekvens observerar Kroll (1961) en fördröjning av responsen på stimulus 2 med ca 150 ms. Nickerson (1965) finner vid stimulusintervallet 100 ms mellan två visuella stimuli den genomsnittliga fördröjningen av 55 ms för stimulus 2.

Enligt den s.k. enkanalprincipen tolkas fördröjningen i responsen på stimulus 2 såsom en blockering av den centrala bearbetningen av denna på tidig nivå, tills bearbetningen (identifieringen) av S_1 fullbordats (Welford, 1959; Davis 1955; jfr äv. Broadbent, 1958):

$$RT_2 = RT_N + RT_1' - I; \text{ då } I < RT_1.$$

där

RT' = central bearbetningstid för S_1 (första stimulus)

RT_2 = Predicerad RT för S_2 (andra stimulus)

RT_N = genomsnittlig "normal" RT för S_2 då denna presenteras ensam.

I = tidsintervall mellan S_1 och S_2 .

Monnier (1952) har sökt kvantifiera de centrala och perifera förloppen som ingår i den totala reaktionen R och har därvid erhållit värdet 30 ms för retinala processer i initialskedet (vid ljusstimulus). Vid verbalresponser har härletts värdet 72 ms för "verbal aptering" (förberedelse till verbalrespons) plus muskulär verbalrespons (Vorckel, 1927, /cit. av Woodworth, 1945, s. 331/). Vi får således en approximativ tid av 100 ms för retinala, verbalapterande och verbalmuskulära processer vid visuell stimulering. Med vetenskap om den totala verbala RT kan en approximativ tid för de mellanliggande associativa (kognitiva) processerna beräknas (central integrationstid).

Fraisse (1963) påvisar en avsevärd ökning av RT för verbala stimuli med intensiteter strax över igenkänningströskeln jämfört med starkare intensiteter. Monnier (1952) observerar vid lågintensiva ljusstimuli en ökning av den retinala tiden (tiden mellan stimuleringsögonblicket och en i ERG identifierbar s.k. b-potential) och därmed av RT, som funktion av minskad stimulusintensitet. Av dessa två resultat skall här endast slutas, att empiriskt stöd icke er-

hölls för att den centrala integrationstiden skulle minska vid reducerad stimulusintensitet.

Om därför central bearbetning av S_a i föreliggande experiment förekommer till sådan nivå att någon form av frivillig av instruktion styrd identifiering skulle kunna göras, skulle situationen i princip kunna återföras på ovan refererade experiment med två supraliminala stimuli. Därvid skulle den kognitiva bearbetningen av S_a medföra en fördröjning av responsen på S_b , oberoende av ljusintensitetsskillnaderna. Kvantitativt skulle fördröjningen vara åtminstone approximativt predicerbar, enligt följande:

Om endast en "primitiv" aspekt av S_a medvetet varseblives (ljus, linjer, e.d.), skulle en fördröjning av responsen på S_b av 80-90 ms kunna förväntas (jfr Davis, 1959; Elithorn & Lawrence, 1955). Om även ordets abstrakta mening medvetet varseblives, skulle en avsevärt större fördröjning förväntas. Storleken av denna kan approximeras utifrån den genomsnittliga reaktionstiden för ett ord som betecknar en av fyra kända möjliga färger, 386 ms (Fraisse, 1964). Central bearbetningstid för identifiering av meningen hos en sådan stimulus kan enl. ovan approximeras till ca 286 ms.

Den observerade RT för S_b vid enkelexponeringar är i detta experiment 553 ms. Om vid presentation av sekvensen $S_a S_b$ en "primitiv" aspekt av S_a medvetet varseblives, skulle enl. ovan den teoretiskt förväntade RT för S_b bli $RT_b = 553 + 85 \approx 638$ ms, vid intervallet 50 ms. Om dessutom medveten identifiering av ordets mening sker, blir den teoretiska fördröjningen lika med integrationstiden för S_a minus stimulusintervallet, dvs. $286 - 50 = 236$ ms. Förväntad RT för S_b blir därför $553 + 236 = 789$ ms. (Denna förväntade tid får dock i detta experiment betraktas som ett minimum, med tanke på det speciella störningmoment inkongruensen vid de aktuella stimulusparen utgör).

Det observerade medelvärde för presentationer av sekvensen $S_a S_b$ och subliminal S_a är 573 ms med felspridningen 79 ms. Sannolikheten för att detta medelvärde skulle tillhöra en population med $\mu = 789$ ms är $P < .001$. Detsamma gäller medelvärde vid kongruenta resp. inkongruenta sekvenser.

Vidare konstateras, att medelvärde för RT för S_b i sekvenser där S_a de facto (bortsett från rena gissningar) varit supraliminal (rapporterats korrekt) var 847 ms, ett icke orimligt värde sett utifrån den teoretiskt förväntade 789 ms el. däröver (se ovan). Signifikansprövning av de intraindividuela differenserna i RT för S_b mellan betingelserna supra- och subliminal S_a ($M = 846$ ms, resp. 578 ms, $s_D = 22.40$) ger ett P-värde för 0-differens av $P < .0005$ ($t = 5.09$, $fg = 18$, $N = 19$, test av differensen mellan två korrelerade samples).

Av beräkningarna framgår således, att fördröjningen av responsen på S_b vid betingelsen "subliminal S_a " ej är av samma storleksordning som den teoretiskt förväntade vid två supraliminala stimuli. Detta gäller såväl de teoretiska värdena för identifiering av enkla figurala aspekter av S_a som av den symboliska meningen. Omvänt observeras däremot, att RT för S_b vid enl. rapporteringskriteriet supraliminal S_a ansluter tämligen väl till det teoretiskt förväntade värdet för betingelsen två supraliminala stimuli.

Den slutsats som kan dragas härav är, att vi vid betingelsen "subliminal" (icke rapporterbar) har att göra med ett kognitivt förlopp som skiljer sig från det gängse vid supraliminal perception i första hand däri, att den förra kräver avsevärt mindre bearbetningstid, och sannolikt även -kapacitet; så snart p.g.a. fluktuerande tröskelförhållanden t.ex. p.g.a. variationer i uppmärksamheten, fp mera effektivt kommer att utnyttja stimulusdosen, erhålles också en plötslig ökning av graden av central bearbetning, varvid S_a medvetet identifieras. Men den ökade aktiviteten innebär också, att mera bearbetningskapacitet utnyttjas. Om krav på maxi-

mal responshastighet då föreligger, medför den ökade aktiviteten också en ökning av reaktionstiden för den i tiden närliggande S_b .

Mätningen av effekten av S_a sker i omedelbar anslutning till exponeringen av S_b (intervall 50 ms). Detta betyder, att identifiering av S_a (subliminal) måste ha skett inom loppet av 50 till 75 ms efter exponeringen av denna stimulus, varefter (varvid) kognitiv interferens med identifieringen av S_b kunnat ske. Med andra ord, förändringar i kognitionen av S_b som funktion av subliminal S_a i meta-kontrastsituationen tycks uppstå primärt vid själva avkodningen av S_b och således ej såsom sekundära minnesförändringar mellan identifiering och rapportering av S_b . Sannolikt gäller detsamma vid fenomenologiska förändringar i S_b som funktion av S_a .

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Vidare konstateras, att medelvärde för RT för S_b i sekvenser där S_a de facto (bortsett från rena gissningar) varit supraliminal (rapporterats korrekt) var 847 ms, ett icke orimligt värde sett utifrån den teoretiskt förväntade 789 ms el. däröver (se ovan). Signifikansprövning av de intraindividuela differenserna i RT för S_b mellan betingelserna supra- och subliminal S_a ($M = 846$ ms, resp. 578 ms, $s_D = 22.40$) ger ett P-värde för 0-differens av $P < .0005$ ($t = 5.09$, $fg = 18$, $N = 19$, test av differensen mellan två korrelerade samples).

Av beräkningarna framgår således, att fördröjningen av responsen på S_b vid betingelsen "subliminal S_a " ej är av samma storleksordning som den teoretiskt förväntade vid två supraliminala stimuli. Detta gäller såväl de teoretiska värdena för identifiering av enkla figurala aspekter av S_a som av den symboliska meningen. Omvänt observeras däremot, att RT för S_b vid enl. rapporteringskriteriet supraliminal S_a ansluter tämligen väl till det teoretiskt förväntade värdet för betingelsen två supraliminala stimuli.

Den slutsats som kan dragas härav är, att vi vid betingelsen "subliminal" (icke rapporterbar) har att göra med ett kognitivt förlopp som skiljer sig från det gängse vid supraliminal perception i första hand däri, att den förra kräver avsevärt mindre bearbetningstid, och sannolikt även -kapacitet; så snart p.g.a. fluktuerande tröskelförhållanden t.ex. p.g.a. variationer i uppmärksamheten, fp mera effektivt kommer att utnyttja stimulusdosen, erhålles också en plötslig ökning av graden av central bearbetning, varvid S_a medvetet identifieras. Men den ökade aktiviteten innebär också, att mera bearbetningskapacitet utnyttjas. Om krav på maxi-

mal responshastighet då föreligger, medför den ökade aktiviteten också en ökning av reaktionstiden för den i tiden närliggande S_b .

Mätningen av effekten av S_a sker i omedelbar anslutning till exponeringen av S_b (intervall 50 ms). Detta betyder, att identifiering av S_a (subliminal) måste ha skett inom loppet av 50 till 75 ms efter exponeringen av denna stimulus, varefter (varvid) kognitiv interferens med identifieringen av S_b kunnat ske. Med andra ord, förändringar i kognitionen av S_b som funktion av subliminal S_a i meta-kontrastsituationen tycks uppstå primärt vid själva avkodningen av S_b och således ej såsom sekundära minnesförändringar mellan identifiering och rapportering av S_b . Sannolikt gäller detsamma vid fenomenologiska förändringar i S_b som funktion av S_a .

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